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# Bulletin

*of the*

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BULLETIN
OF THE
TORREY BOTANICAL CLUB

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# The Sterility of Sparks Aconite

WILLIAM JOHN BONISTEEL

(WITH PLATES 9–12 AND FIVE FIGURES)

The aconite horticulturally known as Sparks Variety has been propagated exclusively as a clone. In all the years since its introduction in 1898 there has been no record that any member of this clone has ever produced seed. The studies here reported have been made (1) to test this sterility in respect to seed formation by controlled and adequate pollinations and (2) to determine by cytological methods the conditions in sporogenesis which are involved in the abortion of pollen.

## THE HISTORY, TAXONOMIC STATUS AND DESCRIPTION OF SPARKS ACONITE

This clone was introduced by Messrs. Maurice Pritchard about 1898 (10). It was obtained from a garden in Hampshire, England, and named after a gardener on the nursery staff whose name was Sparks. Sparks Aconite is widely grown and listed in horticultural literature. Standardized Plant Names (11) lists this clone as "Sparks Aconite (Hort. var. of *Aconitum napellus*)." Nursery catalogs list this clone as "*Aconitum napellus*, Spark's Variety," but it is certain that all plants of this type constitute a clonal variety. This clone has been considered a hybrid but no one has adequately related this clone to any species as parents. Gáyer (5) in his taxonomic treatment of European aconites makes no mention of Sparks Aconite. I know of no adequate description of this clone in the literature. Since there is evidence that this aconite is not a true species but only a horticultural clone, I shall refer to this clone as Sparks Aconite. It should be noted that Schafer and La Cour (10) consider that this clone may be a hybrid or one of several hybrids and they note that the taxonomy and origin are not definitely known.

The stem of Sparks Aconite is herbaceous, erect, branching, terete, glabrous and from 7 to 11 millimeters in diameter. It has a height of 1 to 1.5 meters under good cultural conditions. The leaves are alternately arranged on the stem and they are single, petiolate, glabrous, and lacin-

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ately divided. The leaves on a single stem are few in number and seldom more than ten are present.

In the genus *Aconitum* specialization of floral structures extends to the essential organs of the flower itself. Important characteristics are also found in the underground portions of the plant. Schafer and La Cour (10) have divided the genus *Aconitum* into three sections, based upon the underground nature of the tubers and roots. The first, of which only one species is known, is represented by the annual *A. gymnandrium* Stapf. The second section, LYCOCTONUM, has perennial rhizomes and contains approximately 25 species or clones. The third section, EUACONITUM, is characterized by tubers and various shades of blue flowers and is represented by approximately 150 species or clones. A subsection of this last group includes *A. anthora* which has tubers but differs in that the petals are persistent.

Sparks Aconite belongs in the EUACONITUM section but differs from all the species or other clones of the section in great vigor of growth especially exhibited by the large number of daughter tubers that are produced. As many as thirteen may be present at one time, all attached to a single mother tuber. Especially is this in marked contrast to many other aconites that produce but one or at the most three daughter tubers annually for a single mother tuber.

The inflorescence of this clone is a raceme developing as a cymose panicle below. The terminal flower cluster with an average of nine flowers is the first to bloom. From eight to twelve lateral branches arise from the main stem and these are further sub-divided. After the terminal branch blooms the laterals continue the flowering in their descending order. Thus there is a continuous shed of pollen for almost the entire blooming period of any plant.

More than 25 per cent of the flower buds are aborted. Bud abortion is greatest in certain sub-lateral branches but may affect a series of three or more flowers placed elsewhere. These buds wither but do not drop from the floral branch until the entire period of flowering is over. This condition is typical of Sparks Aconite. Plants of this clone were grown in various soil and moisture conditions. The extent of the abortions of flowers is quite the same for plants grown in dry, in semi-dry and in various grades of moist soils. This condition seems systemic for Sparks Aconite and seems not to be related definitely to moisture in the soil. Yet a considerable proportion of normal flowers always develop. Peloric flowers are found occasionally in most of the plants either as a terminal or a basal flower in an individual inflorescence. Nectaries are seldom present in these flowers, or, if present, they are so abnormally placed as to be of little or no benefit as far as insect visitation is concerned.

In Sparks Aconite outstanding vigor is seen in the large number of flowers which are produced. A well grown plant will have an average of 150 flower buds on a single flower stem. No other member of the EUACONITUM group has such a large number of flowers. The flowering period of a single stem extends from 35 to 45 days. Individual flowers persist for a period of seven days. These flowers are deep blue in color and when compared with Ridgway's color chart are designated as Bradley's violet.

The pistils of the well developed flowers of Sparks Aconite appear normal for some days after the pollen is shed whether there is pollination or not. The carpels increase in size but the ovules wither in two days after the pollen of the individual flower is shed. Aborted pistils are frequently found. Examination shows that the ventral sutures of many of the carpels are not closed in which case the ovules may be exposed. Examination of serial sections shows that many of the sutures in young carpels have gaps of varying degrees. These sections also show at times the presence of accessory but poorly formed anther sacs formed in the wall of some of the carpels, but none of these dehisce to shed microspores. Normal secretion is present upon the stigmatic surfaces when they are fully expanded and it persists for two days.

The flowers of the clone may open at any time of the day or night and one or more stamens will be found shedding pollen at the time when a flower opens. Progressive shedding of pollen occurs until all of the 50–56 anthers have dehisced. The complete period is about four days. Somewhat less than 24 hours elapse after the last pollen discharge before the stigmatic lobes of the 1–3 carpels in each flower are open. When pollen, as it often does in selfing, falls upon the unopened stigma it is pushed aside when the stigma unfolds later. This is a matter to be especially considered in making proper hybridization crosses. There is a succession of anthers in dehiscence varying over a period of four days but the last pollen for a flower is shed before the pistils of that flower seem to mature.

All aconites show some degree of dichogamy. In Sparks Aconite protandry is complete for all flowers that open and self-pollination is apparently not possible. The individual flowers shed pollen for a period of four days; then a period of nearly 24 hours occurs before the pistils are receptive. With a succession of flowers the number of flowers that is open at the same time fluctuates and for a considerable period of time, especially during the middle of this blooming period, there is chance for close-pollination so that it is possible for the proper pollination of many flowers. Hence the condition of dichogamy is not responsible for the complete and continual failure of seeds to form for any of the flowers.

It can be concluded that aborted flower buds, peloric flowers, and pistil abnormalities act together to reduce seeding. But in respect to

dichogamy (12) there are numerous flowers which appear normal and there is opportunity for proper close-pollinations or for proper intra-clonal pollinations especially when there is a group of individuals in flower. Hence the conditions operating to effect the complete sterility of seed production are to be sought in the nature of the spores and germ cells.

## EXPERIMENTAL TESTS FOR SEED PRODUCTION

Pollinations were made to determine whether the pistils and ovules of Sparks Aconite are able to yield seeds to any kind of pollinations. Controlled pollinations were made with the use of glassine bags. The flowers involved were emasculated just prior to their opening. It is necessary to remove the nectaries since ants prove troublesome and can effect pollination through visits from plant to plant. We may note that these precautions, while advantageous in controlled hybridizing pollinations, were not involved in this experiment since seed was never set to any kind of pollination.

A total of 451 close-pollinations were made over a total period of three years. Plants of the clone from seven different sources were used. A total of 181 intra-clonal-pollinations were made. As will be reported later, pollen germination tests revealed but one-half of 1 per cent viable pollen. Since the pollen of one anther of Sparks Aconite contains between 300 and 500 pollen grains, one should expect at least two or three good grains to be present in the pollen applied yet in no case was a seed set.

Hybridizing pollinations were made with pollen of approximately 50 different aconites. Many of these plants were known to produce pollen that is highly viable. No ovules of Sparks Aconite functioned in the setting of seed to any of these hybridizing pollinations.

Observations on plants of Sparks Aconite which grew in a breeding plot beside various other clones and species of aconites with abundant opportunities for open-pollinations have been made for a period of several years. In no instance has a single capsule or seed been formed on any plant of Sparks Aconite. From correspondence and observations in nurseries I find no evidence that seed has ever been produced by plants of this clone.

Utilizing the same aconites that were used in pollinating Sparks Aconite, viable seeds were obtained from over 75 hybridizations. The crosses involved plants of varieties regularly producing viable seed and included diploids, tetraploids and many clones that were triploids. Numerous hybridizations failed. Of the many species used as parents in these hybridizations some plants set seed to close-pollinations. Studies of the pollen of these indicate varying degrees of pollen abortion but for most authentic species pollen viability was high and seed production frequent.

Thus, in the numerous controlled pollination experiments plants of Sparks Aconite have produced no seed to any pollination either close-pollination or hybridizing pollination.

### THE CHROMOSOME NUMBERS FOR THE GENUS ACONITUM

The somatic chromosome numbers reported (1, 2, 8, 10) for somatic tissues in members of the genus *Aconitum* are 16, 24, 32, 48 and 64. These numbers suggest that the basic number is 8. The section LYCOCTONUM (mostly yellow or purplish flowered) which is not discussed in this paper, have, it appears, only 16 chromosomes. The EUACONITUM section in which the Sparks Aconite evidently belongs has all the numbers indicated above.

The species of the EUACONITUM section which possess 16 (2n) chromosomes are usually known only as wild plants and include *Aconitum paniculata; A. variegatum; A. volubile latisectum; A. noveboracense* (reported here for the first time); *A. heterophyllum; A. toppinii; A. transectum; A. Forrestii; A. excelsum; A. yugapense; A. Hemsleyanum; A. barbatum;* and *A. volubile.*

The aconites with 24 chromosomes are commonly cultivated. It is possible that some are representatives of wild species but it is certain that others are only horticultural clones. Of these types those which are reported to have a somatic number of 24 (3n) chromosomes are: *A. Stoerkianum* (8 clones investigated by Afify (1), Schafer and La Cour (10); *A. napellus; A. variegatum;* and Sparks Aconite. Although some of these have been called species it may be that they consist of one or more clones each.

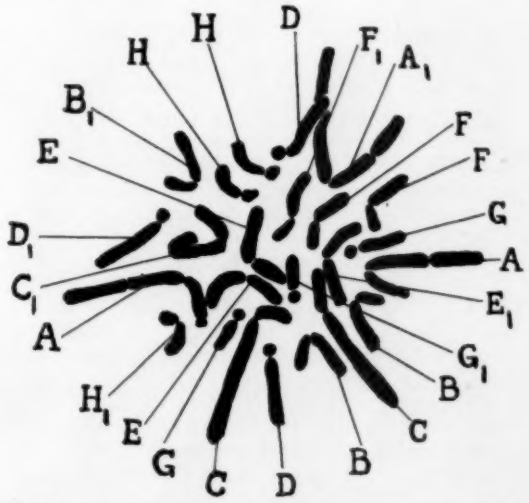


Fig. 1. Somatic chromosomes from the root tip of Sparks Aconite. (3n = 24) Chromosomes identified as A, A and $A_1$; B, B and $B_1$; etc.

Fig. 2. Semi-diagrammatic drawings showing the relative size and shape of the three sets of eight chromosomes each in root tips of Sparks Aconite. The two *A* sets are alike while $A_1$ set differs in certain points as indicated in the description. The descriptions of the chromosomes of Sparks Aconite is as follows:

A and A; 6.3 microns long; median or sub-median constriction; shorter arm constriction with a knob at tip; long arm secondary constriction.
$A_1$; Shorter arm constriction has an extended knob at tip.
B and B; 4.2 microns long; sub-median constriction; shorter arm constriction at right angles.
$B_1$; Shorter arm somewhat bulbous and depressed.
C and C; 5.3 microns long; sub-terminal constriction; terminal knob bent over.
$C_1$ Terminal knob appears compressed against the long arm.
D and D; 5.3 microns long; terminal constriction; erect terminal knob.
$D_1$ Smaller terminal knob and slight twist to long arm.
E and E; 2.5 microns long; median constriction; arm at slight angle.
$E_1$; One arm longer with a slightly twisted knob at apex.
F and F; 1.4 microns long; median constriction; short chromosomes.
$F_1$; Slightly elongated and not so compact.
G and G; 1.8 microns long; sub-median constriction; erect terminal knob.
$G_1$ Knob elongated and bent over.
H and H; 2.1 microns long; sub-terminal constriction; terminal knob bent over.
$H_1$; Knob more erect.

The species or clones which have a somatic number of 32 (4n) chromosomes are: *A. chinese; A. spicatum; A. napellus* (13 clones) (10); *A. Californicum; A. Delavayi; A. Kusnezoffi; A. volubile; A. anglicum;* and *A. paniculata.*

The only species reported which has the somatic number of 48 (6n) chromosomes is *A. palmatum.*

Species or clones reported which have a somatic number of 64 (8n) chromosomes are *A. Wilsoni, A. volubile latisectum* and *A. Delavayi.*

It is of special note that the following types have been reported as having two or more different chromosome numbers:

| | | | | |
|---|---|---|---|---|
| *A. paniculata* | 16 (*10*) | 24 (*10*) | 32 (*10*) | ..... |
| *A. variegatum* | 16 (*10*) | 24 (*6*) | 32 (*10*) | ..... |
| *A. napellus* | ..... | 24 (*6*) | 32 (*10*) | ..... |
| *A. Delavayi* | ..... | ..... | 32 (*6*) | 64 (*10*) |

It is clear either that these plants were improperly identified or that polyploidy has occurred within the species, or that a mixture of types is present in the species.

In my experiments controlled pollinations show that many of these species or clones hybridize freely. However authentic material for breeding experiments can only be obtained from wild stocks or from cultivated plants evaluated by adequate study. Living plants are listed under various names many of which are unreliable. Seeds obtained in the open market give progeny that are variable and from one lot of seed three or more types have been grown. Seeds collected in mixed plantings of species and clones as grown in gardens especially in botanical gardens are liable to yield hybrids.

## CYTOLOGICAL STUDIES OF SPARKS ACONITE*

### *1. Chromosomes in Somatic Tissues*

(*a*) *Triploid number of* (*3n=24*) *chromosomes.*—The rule in the somatic tissues of root tips in members of Sparks Aconite is 3n=24 chromosome. This agrees with Langlet (6) and Schafer and La Cour (10). These chromosomes fall into three groups of eight each for it is possible to identify 8 pairs which are alike while each of the third set differs only slightly (text fig. 1).

The individual chromosomes (text fig. 2) are differentiated by total size, by the position of constriction points, and by the size of the arms.

* Material and Methods: The following killing and fixing solutions gave the best results with root tips: La Cour's 2 BE (7); Allen's modification of Bouin's; Chrom-acetic; Fleming's strong; La Cour's 2 BD; and Navashin's. Sections were cut from 15 to 25 microns and stained usually with Newton's iodine gentian or crystal-violet. Flower buds were examined in temporary aceto-carmine smears. If the desired stage of meiosis was procured the buds were placed in the killing and fixing solutions. Sections were cut

Three chromosomes, here called the A group, are similar but two of the members have a shorter arm constriction with a knob at the tip while the long arm has a secondary constriction. The third A differs from the long pair in that the knob has an extended tip. The sets of three chromosomes identified as F, G, and H are more difficult to determine. The entire complement can be resolved into AA and $A_1$, BB and $B_1$, etc. There are 8 different types of chromosomes with 3 of each type that are noticeably similar and which may be considered as homologs. The distinguishing characteristics of the chromosomes can be traced in somatic metaphases (text fig. 1 and in text fig. 3). In several preparations of root tips collected from different tubers of Sparks Aconite, cells with 6n=48 chromosomes were found along with cells which had only 24 (3n). The cells with the hexaploid chromosome number are larger than adjacent cells with triploid complements. The identity of the individual chromosomes (text fig. 3) was determined in certain of these cells. Sectors of the roots with differing chromosome numbers may be explained in the genus *Aconitum* by chromosome duplication in incompleted mitosis.

(*b*) *Somatic Sectors with the Hexaploid Number* (*6n=48*).—In the survey of the chromosome number of the aconites it was noted that four species are listed with two or more differing chromosome numbers. Both *A. paniculata* and *A. variegatum* are listed with chromosome numbers of 16, 24, and 32. Both *A. napellus* and *A. Delavayi* have chromosome complements listed as 24 and 32, and 32 and 64 respectively. There is a question whether this material was properly identified or whether duplication

from 20 to 30 microns and stained in the same manner as root tips. Buds were preserved in a solution of one part of glacial acetic acid and two parts of absolute alcohol for 24 hours and then transferred to 80 per cent alcohol and held for further study. Belling's method for making aceto-carmine smears proved the most satisfactory. The anther sacs are very small and it was necessary to crush the anthers on a slide with pressure and to remove the anther masses before adding the stain. The early stages are not satisfactory with the aceto-carmine method since it is difficult to remove all the debris of the young anthers.

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**Explanation of Plate 9**

The stages in microsporogenesis of Sparks Aconite.

Fig. 1. Early prophase showing two pairs of homologous chromosomes. One pair shows close homology while the other pair is loose especially at the ends. Gentian-violet. ×2000.

Fig. 2. Association of homologs at first metaphase showing three trivalents, five bivalents and five univalents. Gentian-violet. ×1400.

Fig. 3. Separation of paired homologs of bivalent association during late metaphase of the first meiotic division. Gentian-violet. ×3300.

Fig. 4. Metaphase showing irregular distribution of chromosomes. Gentian-violet. ×1400.

Fig. 5. Anaphase 1 showing lagging chromosomes and irregular poleward movement. Gentian-violet. ×1400.

Fig. 6. Anaphase 1 showing irregular grouping of the chromosomes and spindle abnormalities. Gentian-violet. ×1400.

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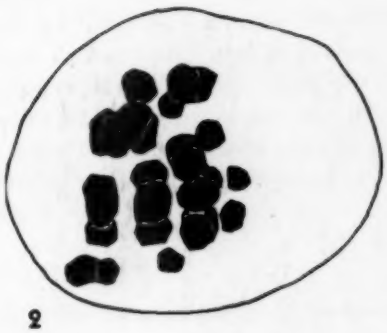
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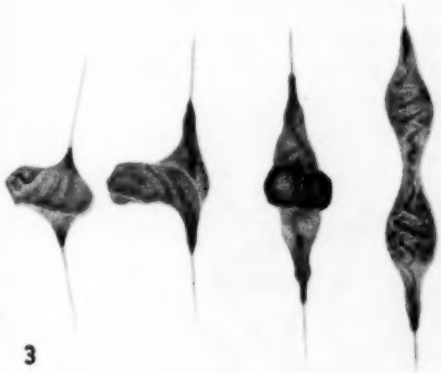
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of chromosomes took place. Schafer and La Cour (10) report tetraploid sectors in the root tips of the diploid (*A. transectum*) and in a clone of *A. vulparia*, which is a species in the LYCOCTONUM group. It is obvious that hexaploid cells in the growing points of stems could develop into a sector of branches and into complete branches which could readily give rise to new types. But thus far no such branches have been observed in any member of the clone of Sparks Aconite.

### *2. Cytology of Microsporgenesis*

(*a*) *Early Stages of Meiosis.*—In Sparks Aconite the early prophases of the first meiotic division show that 24 chromosomes as slender elongated threads in univalent, bivalent and trivalent conditions. The drawing (Plate 9, fig. 1) shows two pairs of homologous chromosomes with each pair in association. In one pair the association is loose especially at the ends, while in the other pair association is fairly close. When three chromosome threads are in association, it is the rule that two of them are more closely paired and twisted about each other, while the third thread is loosely

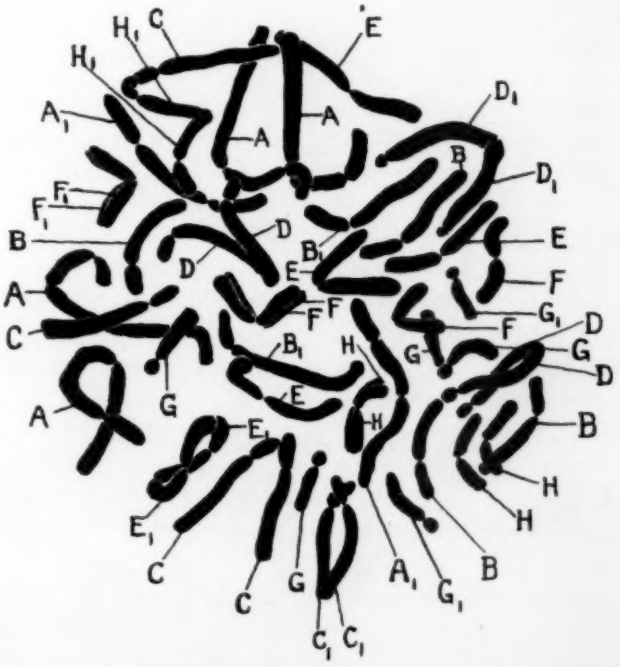


Fig. 3. The somatic chromosomes of an equatorial plate in a single cell from a sector in a root tip of Sparks Aconite in which cells have a hexaploid ($6n = 48$) number of chromosomes. All chromosomes were identified as indicated. Thus four A's and two $A_1$'s are present, etc. (Compare with text fig. 1 and 2).

thrown about the other two with contacts at few points. I have observed at this stage no instances in which three chromosomes were in close association throughout their lengths. After synapsis there is a thickening and shortening of chromosomes and at the extreme contraction in the later stages the chromosomes become short and compact.

Univalents, bivalents and trivalents are found during prophase and early metaphase of meiosis. The frequency of associations was determined from a study of over 100 pollen mother cells (text fig. 4). The number of bivalents in the different cells varied from three to ten with seven bivalent associations occurring 35 times. The number of univalents per cell varied from one to ten. Four trivalents in a single cell were observed but twice. Two and three trivalents were most frequently found in cells. Two trivalents were found 35 times and three trivalents 45 times. Cells with only one trivalent were found 22 times while in a few cases trivalents were absent. The maximum number of trivalents found in any cell was four. Multiple associations of more than three chromosomes were observed in many cells. Thus two cases of quadrivalents were found together with many rings of four and chains of four, five and six chromosomes.

Thus in Sparks Aconite it is obvious that the three sets of chromosomes do not associate in trivalents with regularity. Afify (1) working with *Aconitum Stoerkianum* (3n=24) found that the trivalents varied from five to none. Cells with three and four trivalents were most frequent. The bivalents varied in the different nuclei between two and six and the univalents varied from three to eleven. This condition is not universal however for cases are known in which the complete number of trivalent association is the rule (e. g. *Datura*, Belling 1927).

The number of bivalents necessary to complete the chromosome complement was also compiled (text fig. 5) from the pollen mother cells used in the study. A solid line indicates the presence of univalents and trivalents while a dotted line indicates the number of bivalents which are necessary to complete the chromosome complement. In one case two univalents and two trivalents "2–2" were present, a total of eight, and the number of bivalents necessary to complete the complement is eight. The two or three quadrivalents are not shown on this chart. In 16 cases certain chromosomes were missing or in such a pycnotic condition that they were not recognizable.

(*b*) *Metaphase of the First Division.*—At metaphase there are three sets of eight chromosomes each to assemble at the equatorial plate. Eight trivalents however were never found in any cell. A somewhat typical pollen mother cell at metaphase is shown in Plate 9, fig. 2. In this case there were three trivalents, five bivalents and five univalents. The chromosomes at this stage are characterized by an extremely short and compact form and

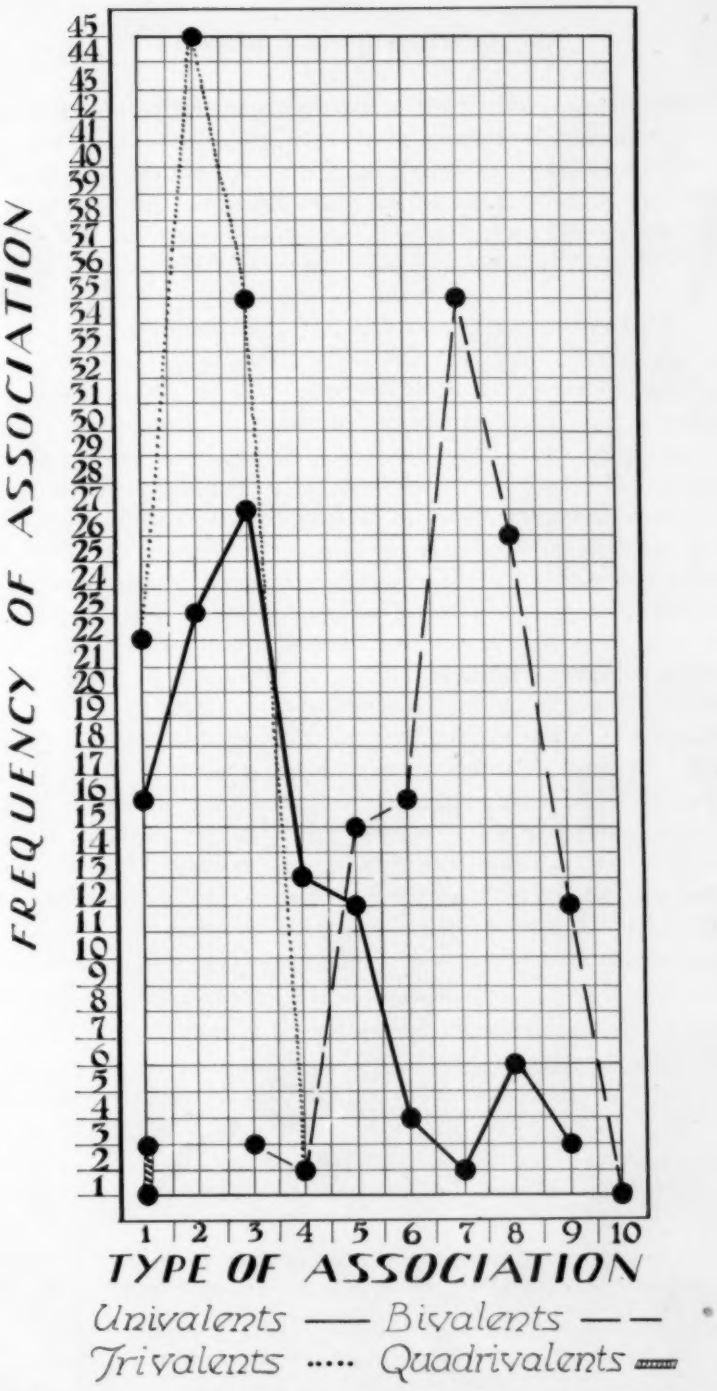


Fig. 4. Frequency of Association in the late stages of prophase of meiosis in the P. M. C.'s of Sparks Aconite. The frequency is plotted on the ordinates while the abscissas indicate the number of chromosomes which are associated.

it is difficult to identify the chromosome after such contraction. The univalents, bivalents and trivalents do not lie evenly on the equatorial plate and lagging elements are found in all material studied. Unpaired chromosomes are found in many of the cells while in other cases some of the chromosomes apparently do not reach the equator but lag (Plate 9, fig. 4). Certain of the chromosomes lay beyond the range of the spindle fibers. At late metaphase the chromosomes are dense but they may become attenuated under tension (Plate 9, fig. 3) when the separation of the paired homologs occurs.

(*c*) *Anaphase of the First Division.*—At metaphase lagging elements were present and the early stages of anaphase are characterized by continued irregularities. Not only are lagging chromosomes to be observed on the spindle (Plate 9, fig. 5) but some of the chromosomes do not advance to the poles normally but stop half-way (plate 9, fig. 6). Chromosomes may remain at the equator when pairs of homologous chromosomes have separated. The general rule is that the separated chromosomes pass to the poles without any separation of their chromatids. The compact nature of these short chromosomes is maintained throughout the stages of first anaphase. There is evidence that the chromosomes having terminal or subterminal spindle attachments show arms after they have separated. But in no case is there a tendency for the chromosomes to form V-shaped figures as reported in the case of first anaphase in many plants. The presence of trivalents and univalents results in irregular distribution. Two chromosomes of a set of three may pass to one pole and one to the other. Unpaired chromosomes may lag at the equator, some show signs of the premature separation of their chromatids while others pass undivided to the poles. In late anaphase examination of both aceto-carmine and

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**Explanation of Plate 10**

The stages in microsporogenesis of Sparks Aconite.

Fig. 1. Anaphase of the second meiotic division of Sparks Aconite showing unequal distribution of the chromosomes to the poles, lagging chromosomes and one chromosome outside the spindle apparatus. Gentian-violet. ×2400.

Fig. 2. Semi-diagrammatic sketch of fig. 1 in which the individual chromosomes are lettered. Chromosome H is outside the spindle and it is evident that it does not reach a pole. Chromosome D is stretched out as a bridge between the two poles.

Fig. 3. Diagrammatic sketch with spindles connecting three of the four nuclei. Iron-haematoxylin. ×1200.

Fig. 4. Upper (1) and lower (11) focus showing late 2nd telophase with faint beginning of cytokinesis in the form of a slight constriction at the middle of the spindle. Iron-haematoxylin. ×1300.

Fig. 5. Incompleted furrowing. Iron-haematoxylin. ×1200.

Fig. 6. Furrowing completed showing four microspores within the wall of the original P. M. C. Iron-haematoxylin. ×1200.

Fig. 7. Tetrads partially collapsed, a frequent stage leading to abortion. Iron-haematoxylin. ×1200.

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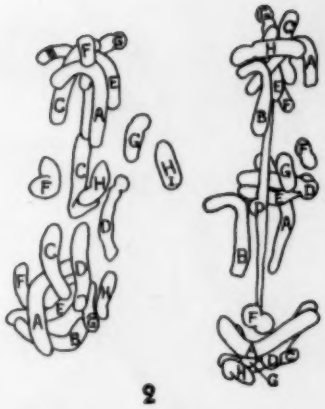

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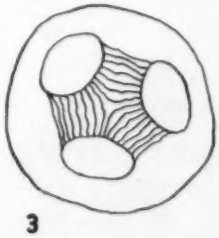

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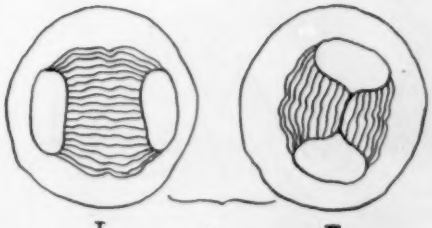

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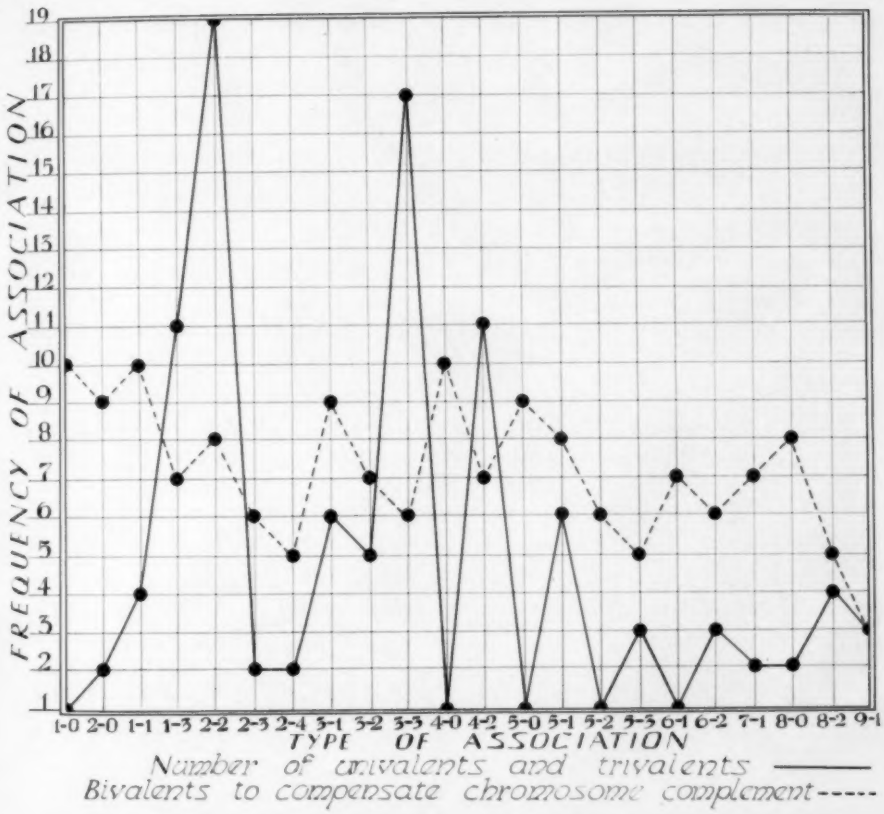


**Fig. 5. Diagram indicating the number of bivalents necessary to complete the chromosome complement for the cases reported in text fig. 4 on the basis of the number of univalents and trivalents observed. The number of univalents and trivalents are indicated in the abscissas 1 — 0; 2 — 0; 1 — 1; etc., in which the first number is the univalent and the second number the trivalent. Both univalents and trivalents are indicated by the dotted line. In the case "2 — 2," there were present two univalents and two trivalents, a total of 8 and the number of bivalents (indicated by the solid line) necessary to complete the complement is eight.**

fixed preparations shows the presence of chromosome elements in the cytoplasm (Plate 11, fig. 1; Plate 12, fig. 1). Some of these chromosomal elements are either chromosomes that were outside the equatorial plate at metaphase or elements that did not move with regularity to the poles. In still other cases certain of the chromosomes are scattered in the cytoplasm. Afify (1) reports in *Aconitum Stoerkianum* (3n=24) that the first anaphase was characterized by irregularities such as lagging, abnormal trivalent separation and the erratic behavior of the unpaired chromosomes which resulted in the poles receiving an unequal number of chromosomes. In the late anaphase of Sparks Aconite chromatin bridges (Plate

12, fig. 2) are frequently found together with extra nuclear chromatin material cast in the cytoplasm (Plate 11, fig. 2). In still other cases chromatin material is present in the cytoplasm after the separated units have rounded up at the poles (Plate 11, fig. 3).

During the first anaphase stages the irregularities are as follows:

1. Univalents may lag, or may lag and then go to the poles and some may disintegrate and become lost in the cytoplasm.
2. Bivalents may lag and there is some evidence that they may fail to separate.
3. Both bivalents and trivalents may fail to separate and often form bridges.
4. In the final distribution of the first anaphase 9 to 11 chromosomes were most frequently found at a pole. Seldom was the entire complement of 24 chromosomes distributed into two groups. Extra chromatin material was usually present outside the two groups at the poles.

(*d*) *Telophase of the First Division.*—The individual pairs of chromatids become slightly elongated and more undulate as the two nuclei are formed. Lagging divided or undivided univalents are found in the cytoplasm. Some of the extra nuclear material rounds up and forms micronuclear structures (Plate 11, fig. 4; Plate 12, fig. 3). Part of this extra

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**Explanation of Plate 11**

Stages in the microsporogenesis of Sparks Aconite. From fixed or acetocarmine preparations.

Fig. 1. Late anaphase of the first division with lagging chromosomes.

Fig. 2. Late anaphase of the first division with chromatin bridge and two extra nuclear chromosomes, apparently lags at metaphase.

Fig. 3. Late anaphase of the first division with extra chromatin material lagging.

Fig. 4. Interphase showing two large nuclei and one micronucleus.

Fig. 5. Telophase at second division with chromatin bridges between daughter nuclei.

Fig. 6. Late anaphase of the second divisions with lagging chromosomes.

Fig. 7. Telophase of second division with two chromatin bridges.

Fig. 8. Telophase of second division with extra nuclear material.

Fig. 9. Telophase of second division with lagging chromatin material.

Fig. 10. Tetrads, complete cytokinesis having taken place.

Fig. 11. Tetrads with lagging chromatin material rounding up.

Fig. 12. Four microspores within an old pollen mother-cell, showing unequal nuclear and cytoplasmic division.

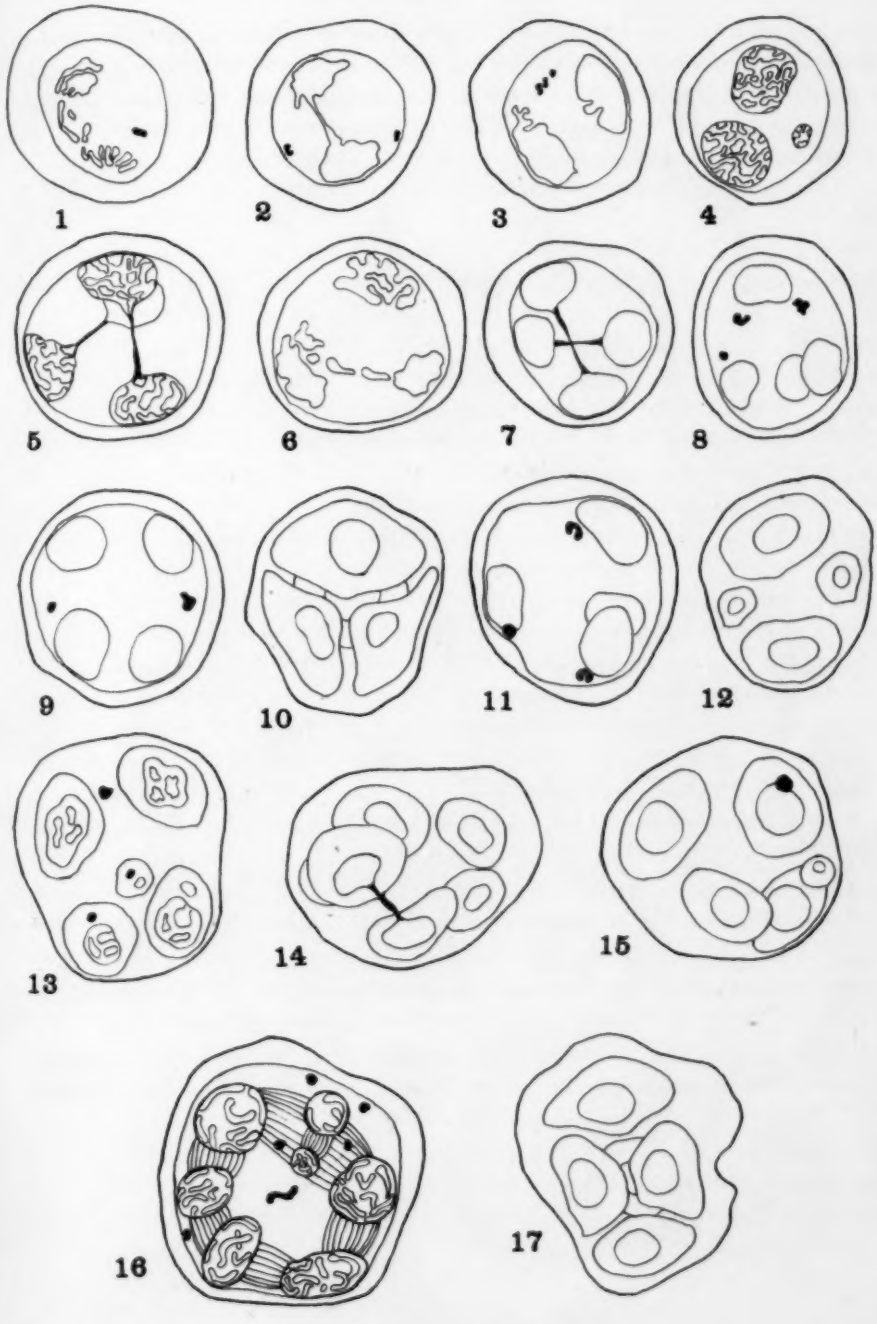
Fig. 13. Polyspory, showing four microspores of equal size and one microcyte. A microcyst, a lag from the first division, is present and within two other microspores a microcyst each. A micronucleus is present in the microspore at lower right.

Fig. 14. Polyspory with six microspores in which two of them are connected by a chromosome bridge.

Fig. 15. Polyspory with a supernumerary microcyte and a microcyst inside one of the spores.

Fig. 16. Polycary, showing telophase of the second division with seven nuclei connected by multipolar spindles and six extra-nuclear microcysts.

Fig. 17. Polyspory with five microspores of equal size.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nuclear material becomes pycnotic and disintegrates during this stage or persists and disintegrates at the end of the second division.

(*e*) *Metaphase of the Second Division.*—The chromosomes are characterized by their irregular form and very seldom could an accurate count be made of them at this stage. Traces of nuclear fragments (whether univalents or not, could not be determined) were found near the periphery of the cell.

(*f*) *Anaphase of the Second Division.*—I have studied many preparations of the stages of second anaphase but have found few cases of distribution in which all of the daughter chromosomes could be identified or even counted. The chromatids separate as daughter chromosomes but many cases of lagging daughter chromosomes (Plate 11, fig. 6; Plate 12, fig. 4) and chromosomal bridges were found (Plate 11, figs. 5 and 7). Yet a study of the later stages of microsporogenesis shows that, as a rule, four large main nuclei are formed (Plate 11, fig. 10). In addition there is frequently one or more micronuclei (3) and microcytes.

One of the relatively few cases in which chromosomes were identified in the anaphase of the second division is shown in Plate 10, fig. 1. A semi-diagrammatic sketch (Plate 10, fig. 2) indicates the daughter chromosomes involved. The lagging and irregular distribution of daughter chromosomes is general for all material studied. It is to be noted that only 40 chromosomes are accounted for in this particular figure. At this stage chromosomes assume a shape and form more characteristic of the somatic chromosomes of the root tip. In this figure the distribution of daughter chromosomes shows that in one spindle there is one pole with six chromosomes while the other has eight. Lagging between these two poles are five chromosomes. One single chromosome (identified as an H) remains outside the spindle and separates from the others. Such separate chromosomes round up and either persist as microcytes or disintegrate at later stages. At the other two poles are seven and five chromosomes with eight chromosomes lagging. Notably is the chromosome D—D stretched out as a bridge between the two poles. Theoretically the total number of chromosomes should be 48 divided equally between the four poles provided that each chromatid formed and separated from its sister and that none was lost or disintegrated. It is to be noted that in the figure the missing chromosomes represent three long and two short ones. Possibly these may have been univalents of the first division that lagged and disintegrated, or perhaps extruded chromosomes (Plate 12, fig. 5) singly or in groups from the major spindle.

(*g*) *Cytokinesis.*—A cell plate is not formed after the first meiotic division but the four or more spores are delimited by partitions which appear at the close of the second division. For a time prominent spindles

(Plate 10, fig. 3) connect the four nuclei. At a later stage the faint beginning of cytokinesis is evident (Plate 10, fig. 4, I and II) when a slight constriction appears at the periphery in the equatorial region of the plasma membrane. Furrows continue (Plate 10, fig. 5) to extend inward until they reach the center and the protoplast is divided into four potential microspores. When cytokinesis is completed the four microspores are still retained within the wall (Plate 10, fig. 6) of the old pollen mother sell. Farr (4) has shown in *Nicotiana* that developing furrows may cut through any spindle fibers that may be encountered by the continued invagination. Frequently at this stage one or more of the developing spores of the tetrads (Plate 10, fig. 7) abort. Later the sporocyte wall and the material separating the spores disappear leaving the spores free. When pressure is applied to aceto-carmine smears at this stage the walls of the sporocyte may be ruptured and the developing spores liberated.

(*h*) *Organization of the Nuclei.*—The most striking condition in the organization of the nuclei after the second division is the unequal size of the nuclei (Plate 11, figs. 10, 12, 13 and 15) formed within a mother cell. One or more nuclei may be full sized while the sister cells may be extremely small (Plate 11, fig. 12; Plate 12, fig. 7). This variation in size is in striking contrast to the organization of the four sister cells in a normal diploid plant such as *A. noveboracense*. More than four spores are frequently found. An extreme condition of supernumerary nuclei is shown in Plate 11, figure 16, in which there were seven nuclei of various sizes with spindle fibers radiating in the several directions of focus. Six extra-nuclear microcysts were also present. Bridging of chromatin material between two nuclei is of frequent occurrence (Plate 11, figs. 5, 7 and 14) in the later stages of division.

The following summarizes the principal abnormal conditions found in the tetrad stage following the telephase at the end of the second division:

1. The nuclei are of unequal size (Plate 11, fig. 13).
2. One fully formed nucleus may be present while others are deficient in chromatin material or are collapsed (Plate 11, fig. 10).
3. Polyspory is of frequent occurrence (Plate 11, fig. 13; Plate 12, fig. 10).
4. Microcysts are present in one or more cells in more than 45 per cent of the tetrads (Plate 11, figs. 13 and 15; Plate 12, figs. 6, 8 and 9).
5. Micronuclei are present in nearly 50 per cent of the tetrads (Plate 11, figs. 8, 9, 11 and 13).
6. Lagging chromatin material is present in the cytoplasm in various stages of degeneration.

## THE MATURE POLLEN

From a statistical study of 250 mature pollen sacs in serial sections, almost ready to dehisce, only 67 well formed pollen grains were observed

and 7013 grains were found that were shrivelled and more or less empty. The few pollen grains that were judged as possibly functional contained granular contents and a vegetative and generative nucleus. Both the exine and intine were well developed. Studies with viable pollen, at the same stage of development, from diploids (*A. noveboracense*, Plate 12, fig. 20, an EUACONITUM type, and *A. Lycoctonum*, Plate 12, fig. 21, a LYCOCTONUM type) show that pollen has both a generative nucleus and a vegetative nucleus. It is to be noted that both of these diploid species set seed freely. The pollen of diploids has three germinal furrows. The relatively few grains that germinate in Sparks Aconite also have three germinal furrows but in the great majority of grains the germinal furrows are poorly developed and some pollen grains (Plate 12, fig. 14) have four germinal furrows. Many of the pollen grains (Plate 12, fig. 18) have collapsed and are of irregular size and of variable shapes. Many of the grains have scattered chromatin material and contain but little cytoplasm and in some cases there is none (Plate 12, figs. 16, 17). It is to be noted that

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**Explanation of Plate 12**

Photomicrographs.

Figs. 1–19. Triploid Sparks Aconite. Figs. 20–22. Diploid Species.

Fig. 1. Late anaphase, first division with lagging chromosomes and one lagging univalent at periphery of the cytoplasm. Aceto-carmine. ×125.

Fig. 2. Late anaphase bridge, first division, with extra chromatin material in the cytoplasm. Aceto-carmine. ×125.

Fig. 3. Interphase with one micronucleus. Aceto-carmine. ×1350.

Fig. 4. Anaphase, second division, with lagging chromosomes. Crystal violet. ×480.

Fig. 5. Telophase, second division, with a chromatin bridge and one microcyst in the cytoplasm. Crystal violet. ×480.

Fig. 6, 7, 8. Tetrad stages. Crystal violet. ×480. Fig. 6. Showing microcysts lying next to the nucleus. Fig. 7. Showing microcyte and two microcysts also next to the nuclei. Fig. 8. Showing microcysts lying next to the nucleus of upper spore.

Fig. 9. Tetrad stages with microcysts. Aceto-carmine. ×100.

Fig. 10. Polyspory with four microspores and one microcyte. Two of the microspores have an additional micronucleus each. Aceto-carmine. ×1350.

Fig. 11–17. Stages in pollen abortion. Freshly shed pollen. Aceto-carmine. ×220. Fig. 11. An ordinary pollen grain with dense contents. Figs. 12 and 13. Aborting pollen grains with chromatin content in various stages of disorganization. Fig. 14. A small pollen grain with four germ pores and one empty microcyte adjacent to it. Figs. 15 and 16. Completely aborted pollen grains. Figs. 17. One normal pollen grain in a field with four completely and three partially aborted pollen grains. Touching one of latter is a free microcyte.

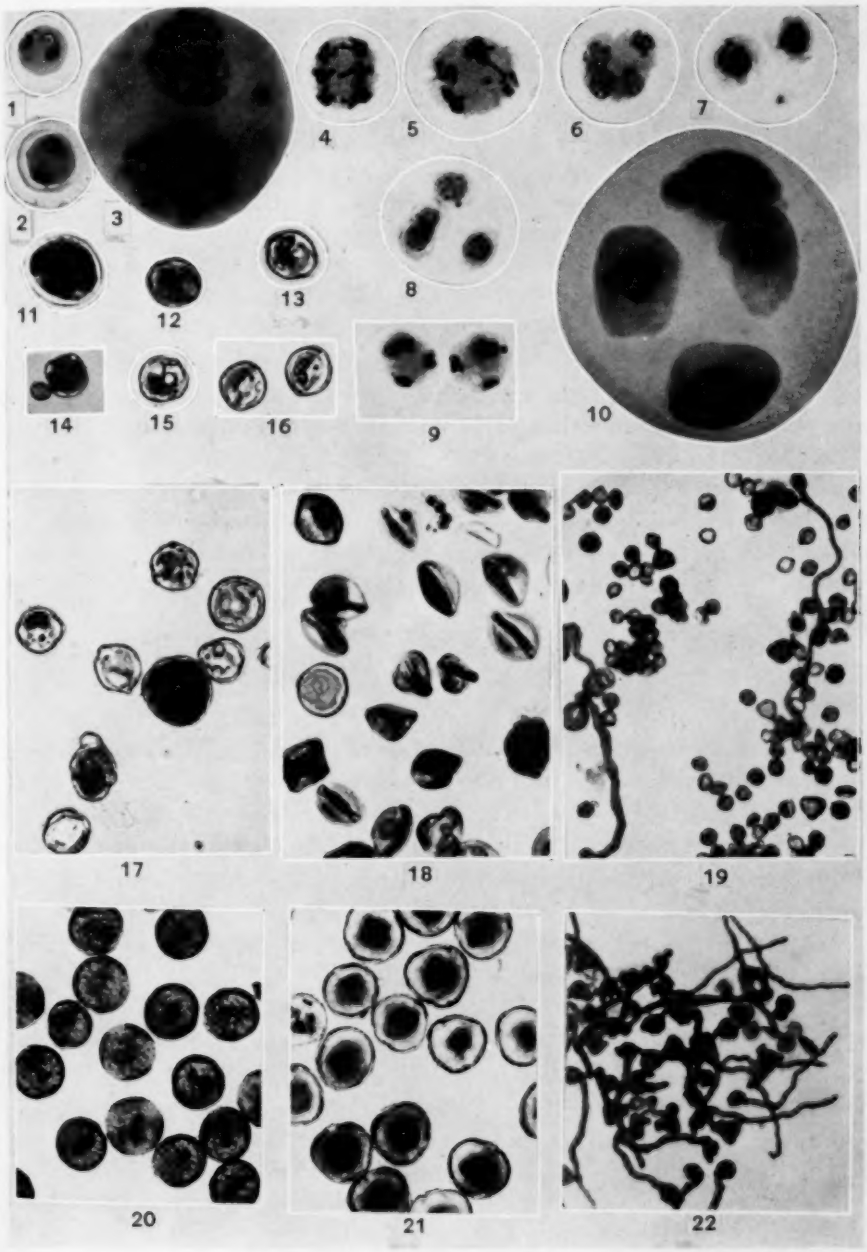
Fig. 18. Microspores just prior to the shed of pollen with but one microspore capable of germinating. Crystal violet. ×220.

Fig. 19. Germination of the pollen of Sparks Aconite. One-half of 1 per cent germination. Aceto-carmine. ×80.

Fig. 20. Mature pollen of the diploid *A. noveboracense*. Crystal violet. ×220.

Fig. 21. Mature pollen of the diploid *A. Lycoctonum*. Aceto-carmine. ×220.

Fig. 22. Germination of the pollen of *A. Lycoctonum*. 95 per cent germination. Aceto-carmine. ×80.

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these grains (Plate 12, fig. 17) are smaller than the few potentially good pollen grains. In all species studied where the pollen functions normally in the productions of seed the content of the cytoplasm is marked. In pollen of Sparks Aconite, as is shown in Plate 12, fig. 17, it is only the very few grains which are plump and appear to be well filled with cytoplasm that will germinate if placed on artificial media. In many of the cells the chromatin material is dispersed in small rounded masses (Plate 12, figs. 12, 13 and 15), while in other cases the primary cell (Plate 12, fig. 11) does not develop further.

## POLLEN GERMINATION TESTS

Pollen of a diploid (*A. Lycoctonum*) in tests for artificial germination on agar (1 per cent agar—sugar 5, 10 and 15 per cent) media gave germination of more than 95 per cent of all grains. Rarely was a collapsed or empty grain found. (Plate 12, fig. 22.)

Pollen of Sparks Aconite when tested gave an average of only one-half of 1 per cent (0.005) germination. Pollen tubes of grains (Plate 12, fig. 19) which germinated reached a length of from 300 to 1200 microns. Some of the tubes branched either soon after emerging from the pore or later.

Microcytes or small cells constitute about 5 per cent of all cells. In freshly shed pollen most of the content of these small grains has already degenerated and merely walls are present. Many pollen grains are collapsed and these grains have little granular content and lack definite pores. Aborted pollen grains constitute about 90 to 95 per cent of all grains. The aborted pollen grains are as a rule somewhat smaller than the few viable grains observed. The primary cell fails to divide in many of the spores. In other spores the presence of small nuclei indicates either unequal division of the primary cell or presence of micronuclei in various stages of degeneration. Dispersed chromatin bodies that take the acetocarmine stain were found in many spores. Degeneration is so universal in this class of pollen that many of the grains possess only walls with very little organized content. Germination of aborted grains was never observed. No increase in germination of pollen was obtained when media was used to which had been added enzymes (diastase, maltase, yeast extracts, etc.) or organic acids (citric, lactic, and malic).

## SUMMARY AND CONCLUSIONS

Plants of Sparks Aconite have never been known to produce seeds. It seems certain that they constitute a clone the members of which have arisen by vegetative propagation of one original plant. Experimental tests show that the plants of this clone are unable to produce seeds with any

kind of pollination. In tests for germination only one-half of 1 per cent of the pollen germinated.

The members of this clone are triploids with 3n=24 chromosomes. The abortions of the microspores arise in connection with the presence of three sets of chromosomes. The three sets of chromosomes function normally in the somatic tissues to produce a plant with marked vigor of growth expressed in the production of flower buds and daughter tubers. But during the complicated process of meiosis abnormalities in chromosomes behavior and distribution arise which lead to abortion of microspores. The ovules are not functional and it is probable that macrospores also abort as do the microspores.

During microsporogenesis the following abnormalities occur (1) irregular conjugation of homologous chromosomes, (2) presence of univalents, bivalents, and trivalents during the first division of meiosis, (3) irregular distribution of the chromosomes in both divisions, (4) the occurrence of polycary, (5) various abnormalities in the later stages of meiosis.

(a) In 60 per cent of the cases the three homologs of each of the eight chromosomes are not closely associated. In a similar number of cases two of the homologs are associated as bivalents without any intimate association of the third homolog. Never has there been found a case where there were either 8 trivalents or 24 univalents. It may be assumed that the bivalent associations which occur most regularly are between homologs of related origin and similar structure while the third, and usually unpaired, homolog is less similar. The irregularities of association together with the presence of three sets of chromosomes are responsible for many of the chromosome aberrations found in the various stages of meiosis.

(b) The distribution of the three sets of chromosomes in the later stages of the first division is irregular. Frequently univalents are left outside the spindle proper and many univalents do not become associated with the spindle in the equatorial plate. As the bivalents separate into their component halves and pass to the poles some univalents are left in the central part of the spindle. The lagging chromosomes may be distributed at random between the two nuclei and some form small supernumerary nuclei or microcytes. The chromatin material that is left outside of the nuclei may degenerate. The two daughter nuclei receive different numbers of chromosomes.

(c) Chromosomes continue to lag in the second meiotic division which results in incomplete distribution of chromosomes to the potential pollen grains. The microspores do not have nuclei of equal size. Micronuclei and microcysts are present in nearly all the tetrads as a result of lagging chromosomes and most of this chromatin material degenerates at a later stage. Polyspory is of frequent occurrence with as many as seven spores

formed from a single spore-mother-cell. Small spores or microcytes constitute about 5 per cent of all spores. When cytokinesis is completed the sister cells do not have their normal complement of chromosomes.

(d) Abnormalities of the microspores may be grouped as follows: (1) small pollen grains with granular contents and limited viability, (2) aborted grains with pycnotic nuclei leading to complete disorganization, (3) completely collapsed empty grains without contents, (4) small microcytes without contents and (5) microcytes which eventually disappear. The numerous chromosomal aberrations prevent the development of the pollen grains that were potentially possible.

The abnormalities which result in the abortion of pollen in the triploid Sparks Aconite are to be attributed chiefly to the presence of a third set of chromosomes. In the meiotic divisions irregularities occur in the pairing of homologs and in the distribution of the members of the three sets of chromosomes so that normal haploid sets, or other complements which may provide for functional spores, are seldom found. It is to be recognized that many irregularities such as these occur both in hybrids and in polyploids, so that such behavior of itself does not differentiate the sterility of hybrids from that of triploids. But here in Sparks Aconite the study of the structure and the character of the 24 chromosomes definitely indicates (1) the triploid nature in the presence of three sets of chromosomes and (2) a condition of hybridity.

Many of the hybrids obtained in these hybridization experiments have already produced flowers. None of the hybrids obtained thus far closely resembles Sparks Aconite. Crosses between clones or species of a decidedly branched habit have resulted in plants that somewhat approximate the branched habit of Sparks Aconite. The species or clones from Asiatic sources, known as *A. formosum* and *A. Forrestii* have in addition to the terminal flower cluster 5–6 lateral branches each bearing 6–8 flowers. These plants readily crossed with European clones and species of the section Euaconitum and some of the hybrids were branched and showed varying degrees of sterility. Sparks Aconite has 8–12 lateral branches, each of which is often further subdivided. This condition suggests the possibility of origin by hybridizing which involves Asiatic species of the Euaconitum section with combinations of certain species not used in these experiments.

In respect to sterilities in certain other aconites Afify (1) states that "diploid *Aconitum* species are sterile although pairing in them is regular, and tetraploid species are also sterile, showing regular pairing as well." Such a condition certainly is not to be expected for the members of any true species, especially of simple diploids, which exist as numerous individuals reproducing by seed, as a true species does. The diploid "species"

to which Afify refers are *Aconitum Lycoctonum* (2n=16), *A. orientale* (2n=16) and *A. luridum* (2n=16). Plants of the first two of these species have regularly set seed during the period of these experiments. *A. noveboracense*, a diploid endemic species of the Catskill mountains, regularly sets seed in the wild so it is not necessarily the case that diploid aconites are sterile.

Afify also studied *A. Stoerkianum* which he described as a triploid and he noted that this so-called species was thought by the systematists to be a hybrid between *A. variegatum* and *A. napellus*. Yet Reichenbach (9) described this plant as producing seeds. *A. Stoerkianum* has also been described as a tetraploid, a fact noted by Afify. Some of the plants of the so-called species described by Afify as sterile diploids may be hybrids between diploid species which have the sterility of hybridity and which must be propagated as clones.

It is certain that Sparks Aconite is a triploid with a somatic number of 24 chromosomes which are to be resolved in three sets. That it may be allotriploid in nature is suggested by the fact that two sets of chromosomes are more nearly alike. Yet the third set is not extremely different. This plant is evidently a hybrid and it could have arisen from (1) two diploid species after a fertilization in which one gamete was unreduced, or (2) one of its parents may have been a tetraploid (or a double diploid) and the other a diploid. In the recent terminology it is considered to be triploid of hybrid origin and according to the terms proposed by Warmke and Blakeslee it would be called a triple haploid.

The writer wishes to express his gratitude to Dr. A. B. Stout under whose directions these studies were carried out and for the opportunity afforded me in carrying out these investigations at the New York Botanical Garden, an affiliate of Columbia University.

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## Literature Cited

1. **Afify, A.** 1933. Chromosome Form and Behavior in Diploid and Triploid *Aconitum*. Jour. Genet. **27** (2): 293–318.
2. ————. 1938. Chromosome Form and Behavior in Tetraploid *Aconitum*. Jour. Genet. **36** (3): 373–394.
3. **Chandler, Clyde, Porterfield, W. M., and Stout, A. B.** 1937. Microsporogenesis in Diploid and Triploid Types of *Lilium tigrinum* with Special References to Abortions. Cytologia. Fujii Jubilee Volume: 756–784.
4. **Farr, C. H.** 1916. Cytokinesis of Pollen Mother Cells. Mem. N. Y. Bot. Garden **6**: 253–317.

5. **Gáyer, G.** 1909. Vorarbeiten zu einer Monographie der europäischen *Aconitum-Arten*. Magyar Bot. Lapok. **8**: 114–206.
6. **Langlet, O.** 1927. Beiträge zur Zytologie der Ranunculazeen. Svensk Bot. Tidskr. **21**: 1–17.
7. **La Cour, L.** 1931. Improvements in everyday technique in plant cytology. J. Roy. Micro. Soc. **51**: 119–126.
8. **Lewitsky, G. A.** 1931. The Karyotype in systematics. Bull. Appl. Bot. **27**: 187–240.
9. **Reichenbach, H. G. L.** 1823–1827. Ill. Speciarum Aconiti Generis, etc. Leipsig.
10. **Schafer, B. & La Cour, L.** 1934. A chromosome survey of *Aconitum*, 1. Ann. Bot. **48**: 693–713.
11. Standardized Plant Names. 1924. Am. Joint Com. on Hort. Names.
12. **Stout, A. B.** 1928. Dichogamy in Flowering Plants. Bull. Torrey Bot. Club. **55**: 141–153.

# A New Species of Cordaites from the Pennsylvanian Strata of Iowa

L. R. Wilson and A. W. Johnston

(with seven figures)

Abundant petrified plant material in the Pennsylvanian coal balls of Iowa has been found and is being investigated by the authors. Some Iowa specimens, which include calcified stems, roots, and leaves of *Cordaites*, were collected in an open pit coal mine at What Cheer, Iowa. The material is from the Des Moines Series of the Pennsylvanian System. Thin sections and nitro-cellulose peels of the specimens were prepared and used in the present paper.

While a number of cordaitean woods have been described from various parts of the world, relatively few are well known in America. In many of the woods there is an absence of primary structure which makes generic determination difficult.

Two stems have been studied from the above locality and these measured about 20 cm. in length and 10 cm. in diameter. The pith region, about three centimeters in diameter, has almost entirely disappeared, and this region now contains several stigmarian rootlets. The pith region is surrounded by a woody ring three to four centimeters in thickness, and bark tissues are not present.

Transverse sections of the specimens indicate a gymnospermous wood with indefinite zones which superficially resemble growth rings (Fig. 1). Under microscopic examination, these zones are found to be the result of collapsing of indefinite layer of cells.

As far as could be determined, the bordered pits of the secondary wood are restricted to the radial walls. The first pits of the tracheids are arranged in several rows, while those of the remainder of the secondary wood are in single rows. The pits occurring in single rows are generally larger than those occurring in many rows, with the former measuring about 10.95$\mu$ in width, and 7.30$\mu$ in height; while the latter measure about 8.62$\mu$ in width and many are less than 7.30$\mu$ in height.

The tracheids seen in tangential sections ranged from 14.60$\mu$ to 54.75$\mu$ in width. The majority being 35$\mu$ wide. In transverse section they are oblong in shape (Fig. 2).

The small, narrow rays vary in height from one to ten cells, the greatest number being two cells high (Fig. 5). The cells are mostly higher than wide, and the cross diameter is about half that of a tracheid. The rays are mostly uniseriate, but several biseriate rays have been observed (Fig. 5).

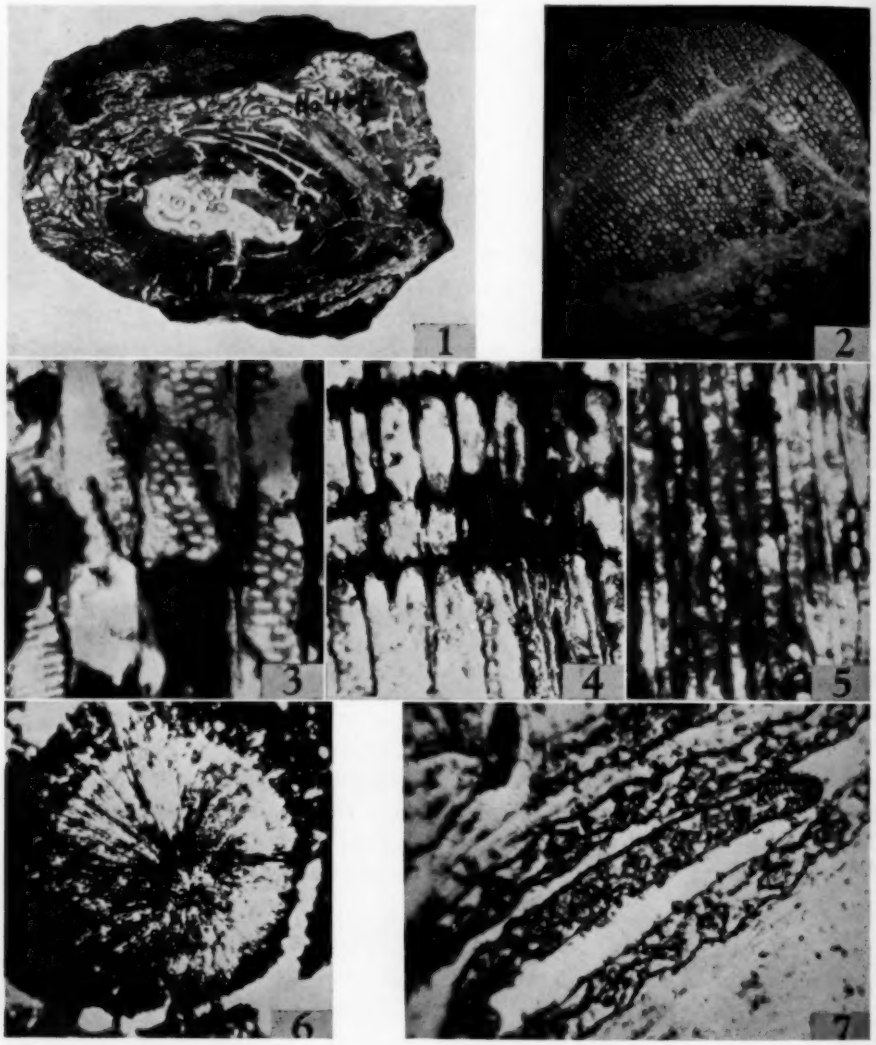


Fig. 1. Coal ball sectioned to show transverse structure of cordaitean stem and leaves.

Fig. 2. Transverse section of stem through the primary and secondary xylem.

Fig. 3. Radial section showing contact of sclariform and pitted tracheids.

Fig. 4. Radial section through secondary xylem showing longitudinal view of wood ray and uniseriate pitting on the tracheids.

Fig. 5. Tangential section through secondary xylem showing tranverse sections of uniseriate rays and one biseriate ray.

Fig. 6. Transverse section of *Amyelon*, a cordaitean root.

Fig. 7. Tranverse sections of cordaitean leaves.

As the rays approach the pith they broaden gradually, becoming narrowly fan-shaped. As a result, the xylem between the rays becomes narrowed to a point at the contact with the pith (Fig. 2). It is largely upon this anatomical character, the presence of a large pith surrounded by a thick zone of secondary wood of the *Dadoxylon* type, a small amount of centrifugal primary wood, and the absence of leaf traces that might designate *Mesoxylon*, that the specimens have been assigned to the genus *Cordaites*.

A review of American and European literature shows that the specimens collected in Iowa evidently represent a new species, which appears to be most closely related to *C. michiganensis* Arnold (1). In contrasting the Iowa fossils with the Michigan, the following characters have been noted:

| *Cordaites michiganensis* Arnold | *Cordaites iowensis* sp. nov. |
|---|---|
| Tracheids regular, average diameter 35$\mu$. | Tracheids regular, average diameter 35$\mu$. |
| Bordered pits in secondary wood mostly in 2 rows, height and breadth equal. | Bordered pits in secondary wood mostly in 1 row, wider than high. |
| Rays low, seldom more than 10 cells high. | Rays very low, seldom more than 7 cells high. |
| Rays only slightly narrower than tracheids. | Rays usually only half as wide as tracheids. |

Associated with the stem remains in the coal balls are abundant leaf fragments of *Cordaites*. These are not sufficiently well preserved to warrant description at present (Fig. 7). In addition a small root was found that can be assigned to the genus form *Amyelon* (Fig. 6).

Since the Iowa fossils do not agree closely with any of the American cordaitean forms described by Arnold (1), Dawson (3), Penhallow (6), and others, nor do they agree with any European forms, it appears advisable to describe them as a new species.

### Cordaites iowensis sp. nov.

Pith large, primary wood narrow and surrounded by a thick zone of secondary wood of the *Dadoxylon* type. Tracheids from 14.60$\mu$ to 54.75$\mu$ in width, average 35$\mu$, oblong in tranverse section and are fairly regular in size. Bordered pits arranged in multiple rows in the first several tracheids possessing them, and in one row in the succeeding tracheids, all slightly vertically flattened. Rays narrow, very low (1 to 10 cells, usually 2), scattered, uniseriate or rarely biseriate. Ray cells slightly higher than wide, and in width about half the cross diameter of the tracheids. Rays broadening as they approach the pith, dividing the centrifugal primary wood region into wedge-shaped segments.

Horizon: Des Moines Series, of the Pennsylvanian System. Locality, What Cheer, Keokuk County, Iowa. Holotype in the collection of the

senior author, No. 4616, and slides have been deposited in the collections of the University of Michigan and Illinois Geological Survey.

The authors wish to express their appreciation for the helpful suggestions of Dr. C. A. Arnold.

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## Bibliography

1. **Arnold, C. A.** 1931. Cordaitean wood from the Pennsylvanian of Michigan and Ohio. Bot. Gaz. **91**: 77–87.
2. **Chamberlain, C. J.** 1935. Coniferophytes-Cordaitales. *Gymnosperms*, structure and evolution. Univ. Chicago Press. Chicago, Ill.
3. **Dawson, J. W.** 1871, 1882. Fossil plants of the Devonian and Upper Silurian formation of Canada. Canada Geol. Surv.
4. **Goldring, W.** 1921. Annual rings of growth in Carboniferous wood. Bot. Gaz. **72**: 326–330.
5. **Maslen, A. J.** 1911. The structure of *Mesoxylon Sutcliffi* (Scott) Ann. Bot. **25**: 381–414.
6. **Penhallow, D. P.** 1900. Notes on North American species of Dadoxylon, with special reference to type material in the collections of the Peter Redpath Museum, McGill College. Proc. Trans. Roy. Soc. Canada II. **6**: 51–79
7. **Renault, B.** 1896. Bassin heuiller et permien d'Autun et d'Epinac. IV. Flore Fossil. Étude Gîtes Minèraux. France.
8. **Scott, D. J.** 1923. Studies in Fossil Botany, Part. II. A. & C. Black, Ltd. London.
9. **Scott, D. J., and Jeffrey, E. C.** 1914. On fossil plants showing structure from the base of the Waverly shale of Kentucky. Phil. Trans. Roy. Soc. London. B. **205**: 345.
10. **Steidtmann, W. E.** 1934. Cordaitean wood from the Pennsylvanian of Kansas. Amer. Jour. Bot. **21**: 396–401.

# Gallatin Petrified Forests[1]

P. A. Young

(with eleven figures)

Tall, yellow petrified logs and stumps protruding vertically from the ground were examined by the writer from 1926 to 1934 on peaks and high ridges of the Gallatin Mountain Range near the northwest corner of Yellowstone National Park (Figs. B,C,F,J,K).[2] Although most of the petrified trees were yellow or brown, a few of them were white, and some pieces of petrified wood were green or black. One white tree showed many small fragments each with only 1 to 5 annual rings, as they were petrified only enough for preservation. One tree hung from the roof of a cave, while the end of another tree trunk was in the wall of a cave. A few tree trunks were inclosed in quartz cylinders (Fig. E), and incrustations of quartz were found on several petrified logs. Many of the petrified trees showed roots, limbs, and bark-like material. Some horizontal logs were found, one of which protruded from both sides of a mountain ridge. Typical specimens of the petrified wood were identified as *Sequoia magnifica* Knowlton by Dr. R. W. Chaney of the University of California. Leaf impressions resembling those of fern, pine, redwood, elm, willow, and magnolia, and a pine cone with seeds were found in the rocks near the fossil trees.

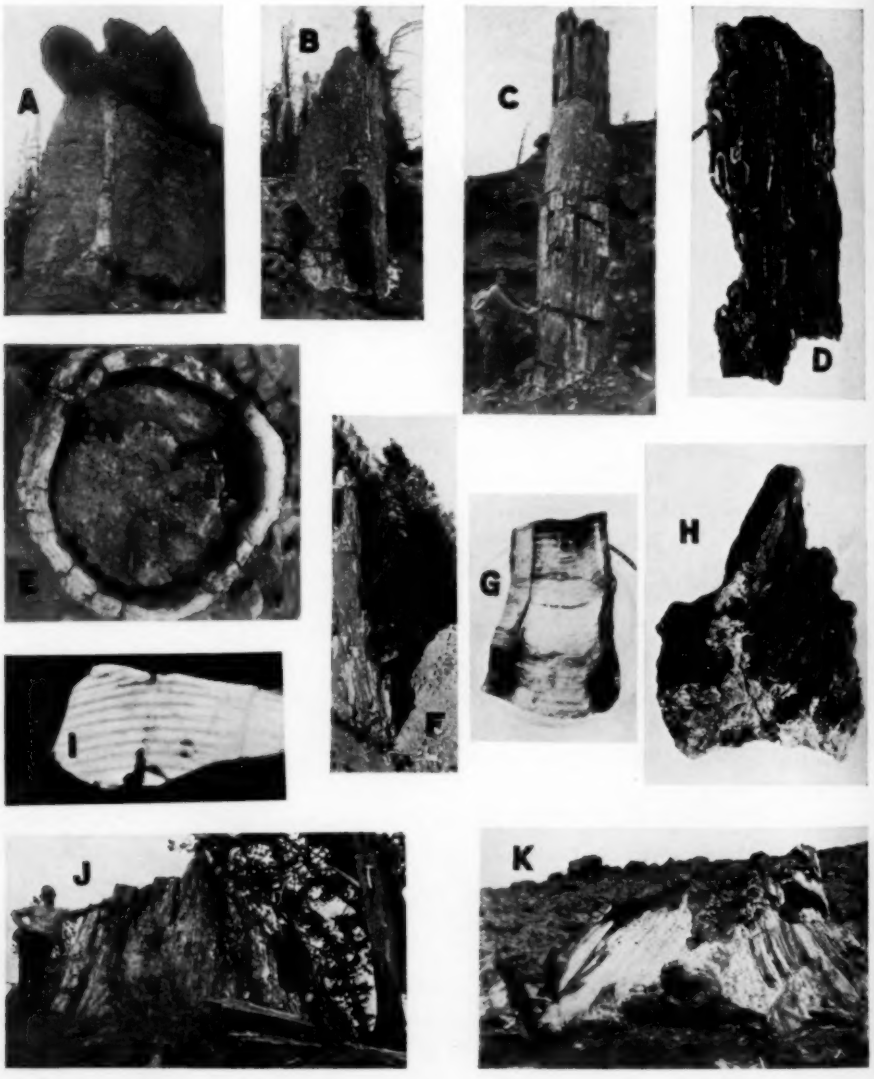
Based on available evidence and preferable theory, the geological history of the Gallatin Petrified Forests is vizualized as follows. A forest predominating in *Sequoia magnifica* grew on nearly level land in a warm, humid climate near a Cretaceous sea.[3] Finally, volcanoes erupted ashes and rocks that broke the limbs from the trees and buried the forest with many of the trunks and stumps standing where they grew. Land subsidence soon placed these trees in a stratum permeated with hot water nearly saturated with silicon dioxide. This petrified the wood enough to preserve it well but left unchanged much of the detailed structure of most of the specimens seen, as they showed prominent annual rings (Fig. G). Petrification probably replaced the wood with silicon dioxide. All of the material solidified into agglomerate rock (Figs. A,F).

In culminating a long ecological succession, another redwood forest grew above the buried fossil forest. The new forest likewise was buried in volcanic ash and rock. It was petrified and its stratum hardened into agglomerate rock on the similar layer below it. Continuing in the Laramie (Upper Cretaceous) and Eocene periods, this whole long process of

[1] Technical paper No. 546 of the Texas Agricultural Experiment Station.

[2] Young, P. A. Gallatin fossil forest. Amer. Jour. Bot. 25(10): 9s. 1938.

[3] Reeside, J. B. The western interior region of North America in later Cretaceous time. Science 87: 466. 1938.




Figures A to K. All except figure I are photographs of petrified wood of *Sequoia magnifica* found in the Gallatin Petrified Forests.

A. Pillar tree 20 ft. tall and 3 ft. in diameter, imbedded in cliff of agglomerate rock; found by writer in 1930. B. Trunk 13 ft. tall and 6 ft. in diameter. C. Trunk 15 ft. tall and 4 ft. in diameter. D. Piece of petrified wood containing many holes and grooves probably made by termites or wood boring beetles before the wood was petrified. ×⅕. E. Top of trunk 9 inches in diameter, inclosed by a cylinder of white quartz. F. Trunk 20 ft. tall and 3 ft. in diameter. G. Annual rings in piece of petrified wood. ×⅓. H. Wood that presumably was rotted by fungi before it was petrified. ×⅐. I. Petrified, yellow, elm-type wood of Oligocene period, found near Madison River. ×⅓. J. Stump 11 ft. in diameter. K. Stump 12 ft. in diameter, found at altitude of 10,000 ft.

ecological succession producing a redwood forest, volcanic rock burying the forest, subsidence of the land and petrification of the trees, and hardening of the stratum into agglomerate rock was repeated until at least 8 layers of fossil forests were buried in horizontal strata, as shown on one ridge (Fig. C).[4] Some of the strata were only a few feet thick and held only stumps and fallen logs, as only the parts of the wood in the agglomerate rock were preserved (Figs. J,K). Other strata were thick enough to hold vertical trunks 13 to 20 ft. tall as shown by the pillar tree with prominent roots and a top limited by the stratum of rock above it (Fig. A).

Some of the *S. magnifica* wood evidently was attacked by wood rotting fungi and boring insects before it was petrified, as effects like theirs were found in pieces of petrified wood (Figs. D,H).

When the Gallatin Mountain Range was raised, the strata bearing the petrified forests formed the upper part of some of the mountains. Erosion exposed parts of the fossil forests where they were found at altitudes of 7000 to 10,000 ft. at many places in an area nearly 40 miles long.

Petrified wood very different from the redwood was found on bluffs of the Madison River about 50 miles from the Gallatin Mountain Range. The specimens from the region of the Madison River presumably came from logs that floated on an Oligocene (Neocene) lake there. The logs were buried in sandy gravel in which they were petrified with silica. The largest log seen was 5 ft. long and 2 ft. in diameter. This petrified wood was white to light yellow and showed finely detailed structure of the tracheae and annual rings (Fig. 1). Recently broken surfaces were shiny on these fossils. This petrified wood probably is referable to a genus now occurring in low latitudes. Like the Gallatin Petrified Forests, the Madison River region merits further scientific study.

[4] Chapman, Wendell and Lucie Chapman. The petrified forest. Natural History pp. 382–393. May, 1935.

TEXAS AGRICULTURAL EXPERIMENT STATION
JACKSONVILLE, TEXAS

# Sex Organs of Angiopteris evecta

ARTHUR W. HAUPT

(WITH SIXTEEN FIGURES)

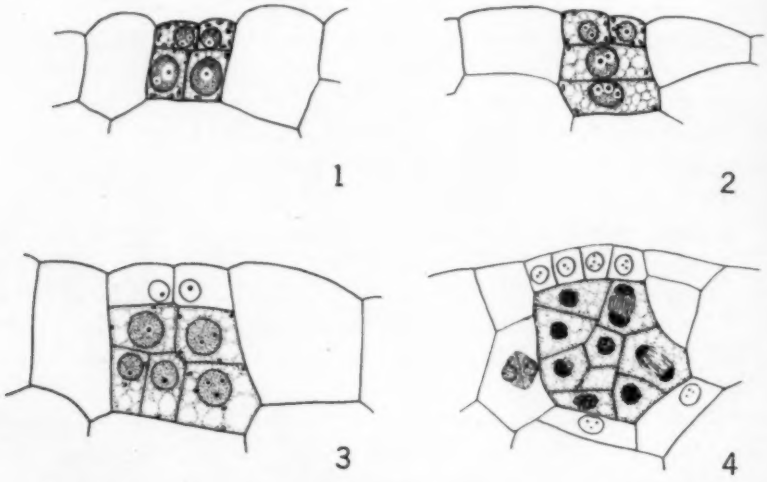
This paper is based on material kindly furnished by Professor W. J. G. Land, of the University of Chicago, who collected, in 1912, on the island of Tutuila, Samoa, many hundreds of gametophytes of *Angiopteris evecta* in various stages of development. A previous paper by Dr. Land (6), based on this collection, has dealt with certain phases of the embryogeny. In it he has fully described the conditions under which the gametophytes were found growing. Early accounts dealing with the gametophyte and sex organs of the Marattiaceae include those of Jonkman (5) on *Marattia* and *Angiopteris*, Farmer (4) on *Angiopteris*, Campbell (1) on *Marattia*, and Campbell (2) on *Kaulfussia*. In his comprehensive monograph of the eusporangiate ferns, Campbell (3) deals with all of the foregoing genera, as well as with *Danaea*. The present study confirms the account, given by earlier authors, of the development of the antheridium, and presents a description, in greater detail than has heretofore been given, of the development of the archegonium.

In the material studied, the largest prothallia were found to be approximately 10 mm. in diameter, but many were smaller. They are at first broadly cordate, becoming almost orbicular at maturity. Growth takes place by means of a group of initials situated at the base of the apical sinus. As in all of the other Marattiaceae, the median portion of the prothallium forms a thick cushion which projects below the ventral surface and gradually merges into the wings, these being but one layer of cells thick at the margins. An endophytic fungus is invariably present in the median portion, the mycelium being intracellular. Unicellular rhizoids arise from the ventral surface, especially from its median portion. The prothallia are monoecious, the antheridia appearing before the archegonia. The latter are borne in large numbers on the ventral side of the prothallium, where they are confined to the median cushion. The antheridia occur on both the upper and lower surfaces. Jonkman (5) found that some of the archegonia are dorsal in position, but Farmer (4) and Campbell (1) found that they are always ventral.

## ANTHERIDIUM

The development of the antheridium resembles that characteristic of all of the eusporangiate ferns. A superficial initial gives rise, by a periclinal division, to an outer primary wall cell and an inner primary spermatogenous cell, the former dividing almost at once by an anticlinal wall, while the division of the latter may be either anticlinal or periclinal

(Figs. 1 and 2). With an increase in the number of spermatogenous cells by divisions in all three planes, the antheridium wall is completed by the cutting off of a layer of cells from the adjacent cells of the prothallium

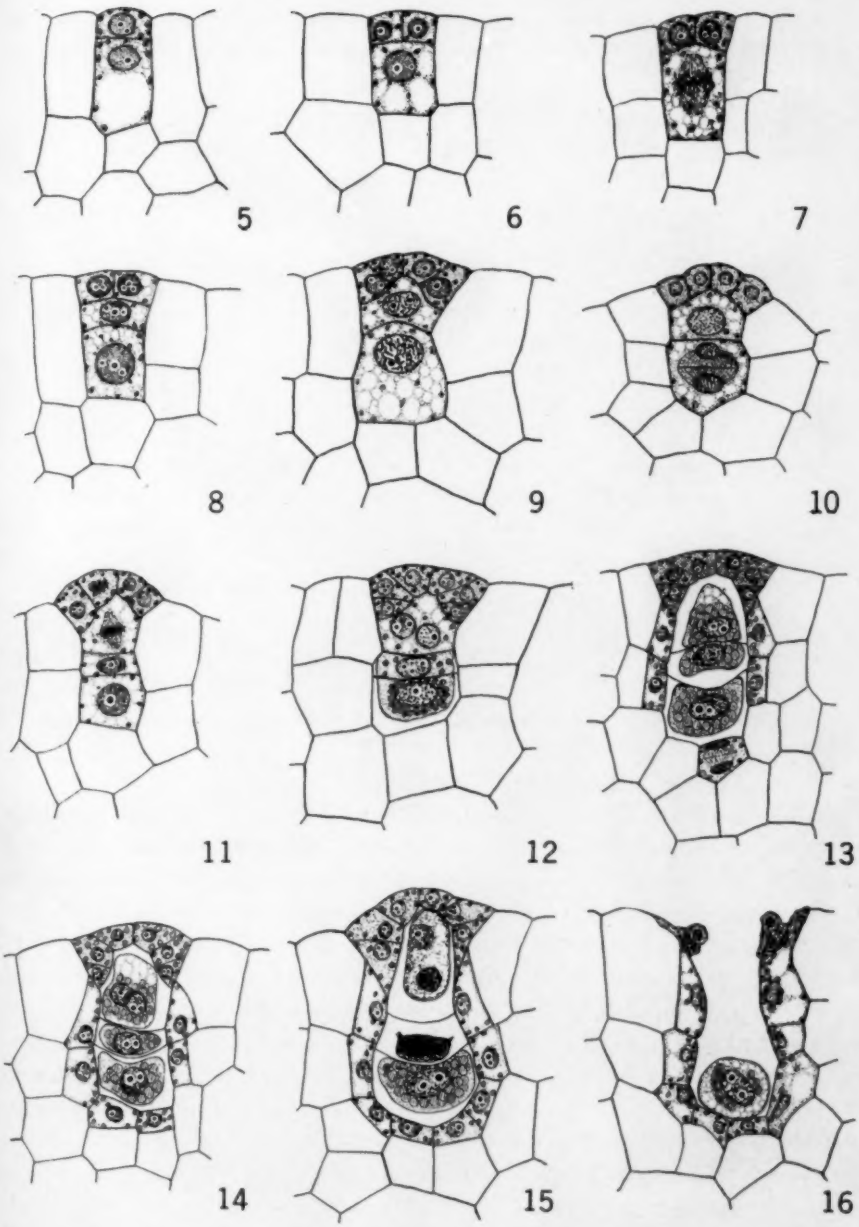



Figs. 1–4. Early stages in the development of the antheridium. ×300.

(Figs. 3 and 4). The later stages, which are well known, eventually result in the formation of a large number of coiled, multiciliate sperms.

### ARCHEGONIUM

The superficial initial which gives rise to the archegonium produces, by a periclinal division, an outer primary neck cell and an inner cell (Fig. 5). The latter does not cut off a basal cell, but functions directly as the "central cell," producing the entire axial row. The primary neck cell, by means of two successive anticlinal divisions at right angles to each other, gives rise to four neck cells (Fig. 6). Then the central cell undergoes a periclinal division to form a ventral cell and a smaller neck canal cell (Figs. 7 and 8). The neck cells now increase in number, forming two tiers of four cells each (Fig. 9). Soon the ventral cell gives rise to the ventral canal cell and egg (Fig. 10). This occurrence is nearly always followed by division of the nucleus of the neck canal cell to form two nuclei that ordinarily are not separated by a wall (Figs. 11 and 12). Meanwhile the number of tiers of neck cells increases to three. The neck projects only slightly beyond the level of the surrounding cells of the prothallium. Soon after the protoplasts of the three cells belonging to the axial row begin to withdraw slightly from their walls, a sterile jacket




Figs. 5–16. Stages in the development of the archegonium. ×270.

is cut off from the surrounding vegetative cells (Figs. 13–16). Typically the ventral canal cell is as large as is represented by the figures, but sometimes it is smaller.

Occasionally the nucleus of the neck canal cell fails to divide as early as has been described (Fig. 13), and possibly may not divide at all. Exceptionally its division is followed by the appearance of a transverse wall, which thereby forms two neck canal cells. Only one such case was observed. Jonkman (5) states that very often a transverse wall appears in the neck canal cell, dividing it into two cells. He figures an archegonium with two neck canal cells in both *Marattia* and *Angiopteris*. Apparently Jonkman did not observe an archegonium with a single binucleate neck canal cell. Farmer (4) reported that the archegonium of *Angiopteris* regularly has two neck canal cells; on the other hand, Campbell (1) found a single binucleate neck canal cell in *Marattia*.

The absence of a basal cell in the young archegonium was a constant feature of all of the material available for the present investigation. This is in agreement with the early observations of Jonkman (5). In *Angiopteris*, Farmer (4) found that a basal cell is usually absent, but he thought that it might be present in a few cases. In *Marattia*, Campbell (1) reported the occurrence of a basal cell, but in *Danaea*, he (3) found a basal cell to be constantly absent. In connection with the Marattiaceae in general, Campbell (3) states that a basal cell is usually, but not always formed. His figures show a basal cell in *Angiopteris* and *Kaulfussia*, but not in *Danaea*.

In its early developmental stages, the archegonium has small plastids which are more numerous than those in the surrounding cells of the prothallium. When the neck canal cell becomes binucleate, however, the plastids in the cells of the axial row increase in number and, by the formation of starch, in size as well (Figs. 13 and 14). The preparation of the egg for fertilization is accompanied by the breaking down of the ventral canal cell, neck canal cell, and neck cells. The egg, assuming a nearly spherical form, lies at the bottom of the archegonial cavity (Fig. 16). Although a great many archegonia are formed, only a few ripen, the rest degenerating. The mature archegonium shown in Fig. 16 is one of three of similar appearance found on the same prothallium.

As soon as fertilization has occurred and an embryo begins to develop inside an archegonium, all of the other archegonia degenerate and no new ones make their appearance. Land (6) says, "The massive archegonial pad bears numerous archegonia, but never more than one has been observed to function. Several thousand individuals were

examined, and never more than one embryo or sporeling was found on a prothallus." He states further that the necks of the functionless archegonia invariably fail to open.

SUMMARY

The development of the antheridium is similar to that of the other Marattiaceae.

The archegonium develops without the formation of a basal cell.

The formation of the ventral canal cell and egg precedes the division of the nucleus of the neck canal cell.

With rare exceptions, a single binucleate neck canal is present.

Several archegonia may ripen at the same time, but fertilization results in the degeneration of all of the archegonia except the one fertilized.

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## Literature Cited

1. **Campbell, D. H.** 1894. Observations on the development of *Marattia Douglasii* Baker. Ann. Bot. **8**: 1–20.
2. ————. 1908. The prothallium of *Kaulfussia* and *Gleichenia*. Ann. Jard. bot. Buitenzorg, 2e sér., **8**: 69–102.
3. ————. 1911. The Eusporangiatae. Carnegie Inst. Washington Publ. no. 140. pp. vi+229, pls. 13, figs. 192.
4. **Farmer, J. B.** 1892. On the embryogeny of *Angiopteris evecta* Hoffm. Ann. Bot. **6**: 265–270.
5. **Jonkman, H. F.** 1880. La génération sexuée des Marattiacées. Arch. néerland. sci. exactes et nat. **15**: 199–224.
6. **Land, W. J. G.** 1923. A suspensor in *Angiopteris*. Bot. Gaz. **75**: 421–425.

# A further Study of Interglacial Peat from Washington

HENRY P. HANSEN AND J. HOOVER MACKIN

(WITH TWO FIGURES)

The Puget Lowland in Northwestern Washington has been subjected to at least two Pleistocene glaciations; the first of which is known as the Admiralty, followed by the Puyallup interglacial period, and the second as the Vashon (Bretz 1913). During the retreat of the Admiralty glacier, considerable ponding of water occurred, as is evidenced by the presence of silts, varved clays, and other types of lacustrine deposits. Peat lenses of varying magnitude are often present at different stratigraphic positions in the sequence of glaciolacustrine deposits. This paper is concerned with the pollen analysis of an interglacial peat stratum in Seattle, Washington (Hansen), and the position of the peat in the stratigraphic sequence in the Puget Lowland (Mackin). In a previous paper, Hansen (1938a) interpreted the forest succession during a brief interval of interglacial time from pollen analysis of a peat stratum located ten miles east of Auburn, Washington. That deposit is probably younger than that of this study, as will be discussed later. The post-Vashon forest succession and climate in the Puget Sound region, as interpreted from pollen analysis of bogs of post-Vashon origin, has also been worked out (Hansen 1938b). These interpretations may serve as criteria in the interpretations of the pollen spectra of this paper.

The peat of this study is located in Beacon Hill, in the south central part of Seattle. Extensive regrading for streets several years ago involved the removal of the Vashon till-mantle, exposing the interglacial sediments which form the core of the hill. The peat lenses crop out in a landslide scarp 210 to 220 feet above sea level, approximately 150 yards south of the Twelfth Avenue viaduct. The total thickness of the peat-bearing bed is about 64 inches. The lowest and thickest lens is about three feet thick; the lower half consisting of gray, silty, limnic peat, and grading upward into fibrous peat, which contains fragments of reed and sedge. This is followed upward by a series of thinner lenses of limnic peat, which contain some silt, and are interbedded by layers of silt and sand.

## GEOLOGIC RELATIONS

### *General Statement*

The Pleistocene stratigraphic sequence in the Puget Lowland, as recognized by Bretz (1913), includes from the base upwards: (1) Admiralty till, (2) Admiralty sediments, (3) Vashon till (Wisconsin age), and (4) post-Vashon glaciofluvial and glaciolacustrine deposits. In the

Seattle area the Admiralty sediments, generally flat-bedded, form the cores of a series of drumloidal hills, elongated in a north-south direction. The hills are enwrapped by a sheet of Vashon till, averaging 20 feet in thickness, but varying from 0 to 100 feet or more. Vashon retreatal sediments are highly variable in thickness and distribution; in general, they may be distinguished from the Admiralty sediments only by their stratigraphic relations to the Vashon till sheet. Bretz believes that the Admiralty sediments originally formed a proglacial aggradational plain in the central part of the Puget Lowland, with the surface of the approximate level of the present hill-tops; that this plain was trenched by north-south stream valleys during the Puyallup interglacial period, and that the valleys and divides were later modified into the present trough-drumloid topography by southward-moving Vashon ice.

### *Relations of Peat to Overlying Deposits*

The relations of the Beacon Hill peats to the enclosing sediments are illustrated by the accompanying figure (Fig. 1). Although the Vashon till is not present in the immediate section, the peat is regarded as pre-Vashon because the overlying blue clays, silts, and gravels can be traced southward along the west flank of the Hill to a point where they are overlain uncom-

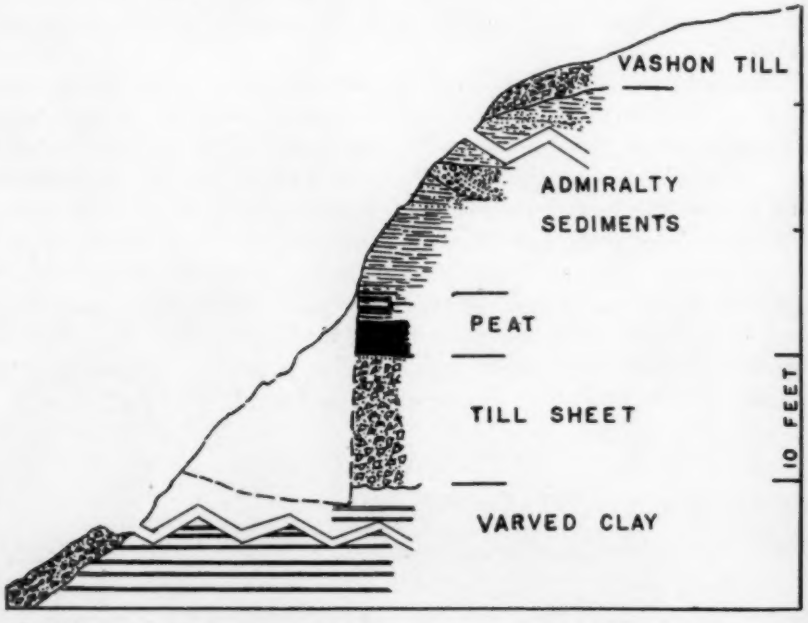


Fig. 1. Diagram showing relations of the Beacon Hill peat. Dashed line indicates outline of pit, excavated largely in rubble.

formably by Vashon till. Numerous cuts in the flanks and crests of adjacent hills show similar relationships. Bretz (1913) states that peat deposits were exhumed in the removal of Denny Hill, one and one-half miles to the northwest, where the relations of the peat layers to overlying Vashon till indicated that they were an integral part of the Admiralty sediments.

### *Relations of the Peat to Underlying Deposits*

Landslide scarps in the lower flanks of the hill, below the level of the peat, show a 110 foot sequence of varved clays, recording approximately 500 years of sedimentation in a glacial lake. These clays are markedly different from the laminated to massive blue clays, with interbedded sand and gravel, which enclose the overlying peat beds. Individual varves are very thick at the base of the exposure, the annual units averaging 15 inches. The units thin progressively upward, averaging 1½ inches in the middle and upper parts of the sequence, but the top varves increase in thickness to a 2½ inch average. The uppermost several layers are 3 foot silt beds. Resting directly upon the silt is a 10 foot till sheet, containing striated pebbles in a gray silt matrix similar to the varve materials. The contact between the varve sequence and the till is sharp, with a 2 to 4 inch zone showing shearing and crumpling. The basal peat lens rests upon the till sheet, with a 6 inch layer of coarse sand at the contact.

The till sheet is not normally exposed at the present surface. The contact of varve, silt, till, and peat were seen in a 14 foot section, in a pit opened at a single place along the hill flank in the vicinity of the peat outcrops where topographic relations and the relative absence of landslides were favorable for excavation. Since critical evidence is not now at hand, two alternative explanations of the relations of the peat to the underlying strata will be outlined briefly.

The first hypothesis holds that the complete Beacon Hill sequence is Admiralty in age, and is in harmony with the regional conclusions of Bretz, although he did not specifically recognize the existence of the varved clays in the Admiralty sediments. According to this view an initial retreat of Admiralty ice permitted the formation of a glacial lake in which varved sediments accumulated for approximately 500 years. Lacustrine sedimentation was brought to a close by readvance of the Admiralty glacier to the latitude of Seattle. Final retreat of the ice was followed by formation of peat, and the deposition of the thick sequence of blue clays, sands, and gravels, the typical Admiralty sediments of Bretz. This hypothesis is supported by the variation in varve thickness described above, since gradation from basal thick layers, to middle thin, to upper thick, suggests retreat followed by readvance.

A minor variation of the foregoing hypothesis attributes the cessation of varve sedimentation to the draining of the lake, the relatively great thickness of the upper varves to the turbidity of the shrinking waters, and the till to a stranded berg. This view finds some support in the thinness of the sheared zone at the base of the till and in the fact that the peat deposits are somewhat thicker over the till than in other parts of the bank, where excavations through the peat failed to discover till at a corresponding level. According to this view the peat accumulated in a kettle pond on the drained lake floor, approximately five hundred years after the Admiralty glacier had withdrawn from the Seattle area.

These hypotheses serve to explain all essential features of the Beacon Hill sequence, but one of the deduced consequences fails of confirmation. The varved clays must have been deposited in a relatively extensive water body, and, if they were formed as suggested above, should be present as a persistent lower member of the Admiralty deposits in adjacent areas. Excellent exposures in sea cliffs north and south of Seattle, however, show no varves, the typical Admiralty blue clays and sands extending from sea level to the hilltop mantle of Vashon till. It is recognized that lateral gradation or deformation might explain these circumstances, but in the absence of evidence favoring either possibility, a second hypothesis seems worthy of consideration.

This alternative hypothesis makes the Beacon Hill varves a part of a sequence of considerable lateral extent, formed in a proglacial lake during a pre-Admiralty glacial stage. The varved sequence then may have been maturely dissected by streams during a pre-Admiralty interglacial period, and the residual hills further eroded and blanketed by Admiralty till and the thick cover of Admiralty sediments. The composite sequence would then have been subjected to erosion by streams during the Puyallup interglacial stage, and finally covered with Vashon drift. This relatively complex history of repeated erosion and burial would explain the lack of continuous exposures of varved clays, particularly in view of the fact that all students of glaciation of the Puget Sound area are agreed that the base of the Admiralty till is generally below present tide level.

The final solution of these problems will require much detailed stratigraphic study, supplemented by pollen analysis, of the Pleistocene sequence in the Puget Lowland. For the purpose of the present paper it should be noted, that in spite of some uncertainties, the geological relations indicate that the peat stratum was deposited during an early stage in the Admiralty deglaciation of the Seattle area.

## METHODS

Eleven peat samples were obtained at approximately six-inch intervals, although this varied somewhat depending upon the thickness of the inter-

bedded silt and sand which separated the upper peat lenses. A foot or more of the face of the exposure was removed in order to secure unweathered and unoxidized material. For study, the peat was pulverized in a mortar, boiled in a weak solution of potassium hydrate, washed, centrifuged, stained with gentian violet, and mounted in glycerin jelly. A total of 113 to 262 pollen grains were counted from each level. The number of pollen grains at each level is approximately indicative of their relative abundance (table 1).

TABLE 1

*Percentages of Pollens at different depths*

| DEPTH IN INCHES | 0 | 6 | 12 | 18 | 24 | 30 | 36 | 42 | 48 | 54 | 62 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pinus contorta | 47 | 60 | 54 | 48 | 30 | 55 | 40 | 42 | 49 | 54 | 39 |
| P. monticola | 7 | 15 | 25 | 23 | 46 | 34 | 20 | 38 | 39 | 34 | 30 |
| Picea sitchensis | 0.5 | 3 | 1 | 1 | 3 | 7 | 33 | 5 | 5 | 6 | 22 |
| Abies grandis | 3 | 1 | .. | 5 | 1 | .. | 1 | .. | .. | .. | .. |
| A. lasiocarpa | .. | .. | .. | .. | 1 | .. | .. | 2 | .. | .. | .. |
| Tsuga | 2 | .. | 1 | .. | 1 | .. | 1 | 1 | 2 | .. | 2 |
| Gramineae | 30 | 8 | 6 | 5 | 10 | .. | 4 | 2 | 3 | 5 | 3 |
| Compositae | 3 | 0.5 | 0.5 | 1 | 2 | 1 | .. | 3 | 1 | .. | 1 |
| Alnus | 4 | 1.5 | 1 | 2.5 | .. | .. | .. | 2 | 1 | .. | 1 |
| Acer | 0.5 | 0.5 | 1 | 7 | 2 | .. | .. | 1 | .. | .. | 1 |
| Betula | 1 | 9 | 8 | 4 | 2 | .. | .. | 3 | .. | .. | .. |
| Salix | 2 | 1.5 | .. | 1.5 | 1 | .. | .. | .. | .. | .. | .. |
| Chenopodiaceae | .. | .. | 2 | 1.5 | 1 | 2 | 1 | .. | .. | 1 | .. |
| Cyperaceae* | .. | 6 | 2 | 31 | 19 | 23 | 50 | 37 | 4 | 22 | 24 |
| Typha* | .. | .. | .. | 12 | .. | .. | .. | .. | .. | .. | .. |
| Sparganium* | .. | .. | .. | 1 | .. | .. | .. | .. | .. | .. | .. |
| Fern* | .. | 9 | .. | .. | 1 | .. | .. | 1 | 6 | .. | .. |
| Unknown* | 53 | 13 | 20 | 21 | 11 | 15 | 14 | 7 | 3 | 10 | 1 |
| Total number | 262 | 218 | 172 | 185 | 122 | 152 | 174 | 175 | 113 | 122 | 155 |

* Number, and not computed in the percentages.

It is realized that at best, pollen analysis and its interpretation is subject to many sources of error, which have been adequately discussed by various workers (Erdtmann 1931, Fuller 1935, Sears 1930). In the analysis of interglacial peat, however, the source of error attributed to age is greatly magnified. Obviously the degree of preservation of the pollens in the peat is one of the important factors in recording the correct representation of adjacent flora during the time the peat was being deposited. The older the peat the greater the chance for destruction of the less durable pollens, and distortion of the vegetative record. Thus it should be borne in mind that the pollen analysis of the peat of this study, and the interpretation of said analysis are discussed with full cognizance of its shortcomings.

## SIGNIFICANCE AND CORRELATION OF THE POLLEN SPECTRA

The forests which existed in the Puget Lowland during the initiation of the peat accumulation, consisted chiefly of lodgepole pine (*Pinus contorta*) and western white pine (*P. monticola*), with an abundance of grass (fig. 2). The frequencies of these are 47, 7, and 30 per cent respectively in the lowest level. This forest, with other species in lesser abundance (table 1), may or may not have been the pioneer forests of the interglacial period. It would be hard to estimate the amount of time which had elapsed between the retreat of the Admiralty ice and the invasion by forests. The second hypothesis concerning the stratigraphic relations, however, indicates that at least 500 years had passed before the beginning of the peat deposition. The initial post-Vashon forests to invade the Puget Lowland, areas near Spokane, Washington, and in Northern Idaho, likewise consisted of lodgepole and white pines (Hansen 1938b, 1939a, 1939b). Each of these areas supports a different forest climax at present, although the initial post-Vashon forest succession was apparently similar. The presence of an abundance of grass in the early postglacial forest succession in Northern Idaho may indicate earlier tundra-like conditions, which had existed previous to forest invasion. Upon the basis of postglacial forest succession, it seems probable that the Seattle area was invaded by forests soon after the retreat of the Admiralty glacier. The percentage of grass pollens decreases from the lowest level to the top with slight fluctuations, and seems to offer no further significance.

Lodgepole pine increases to 60 per cent at 6 inches, and then decreases to 30 per cent at 24 inches. White pine shows a gradual increase from the lowest level, to 46 per cent at 24 inches to supersede lodgepole pine. This probably indicates normal forest succession, because lodgepole is less tolerant of shade than white pine, and is gradually replaced by the latter (Larsen 1930). Lodgepole pine again increases sharply at the next horizon, and then decreases at the 36 inch level. White pine decreases at both levels to record 20 per cent at 36 inches. Sitka spruce (*Picea sitchensis*) shows a sharp and significant increase to 33 per cent at the same level, which is its highest frequency throughout its spectrum. The present range of Sitka spruce indicates its preference for a very humid climate, as it reaches its maximum development in the fog belt area along the North Pacific Coast. Spruce records a sharp decrease to 5 per cent at the next higher level, and remains uniform to the uppermost level, where it again increases to 22 per cent. Lodgepole and white pines again show an increase from the 36 inch level; the first recording 54 per cent at 54 inches, and the latter 39 per cent at 48 inches. Both species decrease in frequency to the top level, with lodgepole recording 39 per cent and white pine 30 per cent. The presence of sedge pollens in all levels sampled

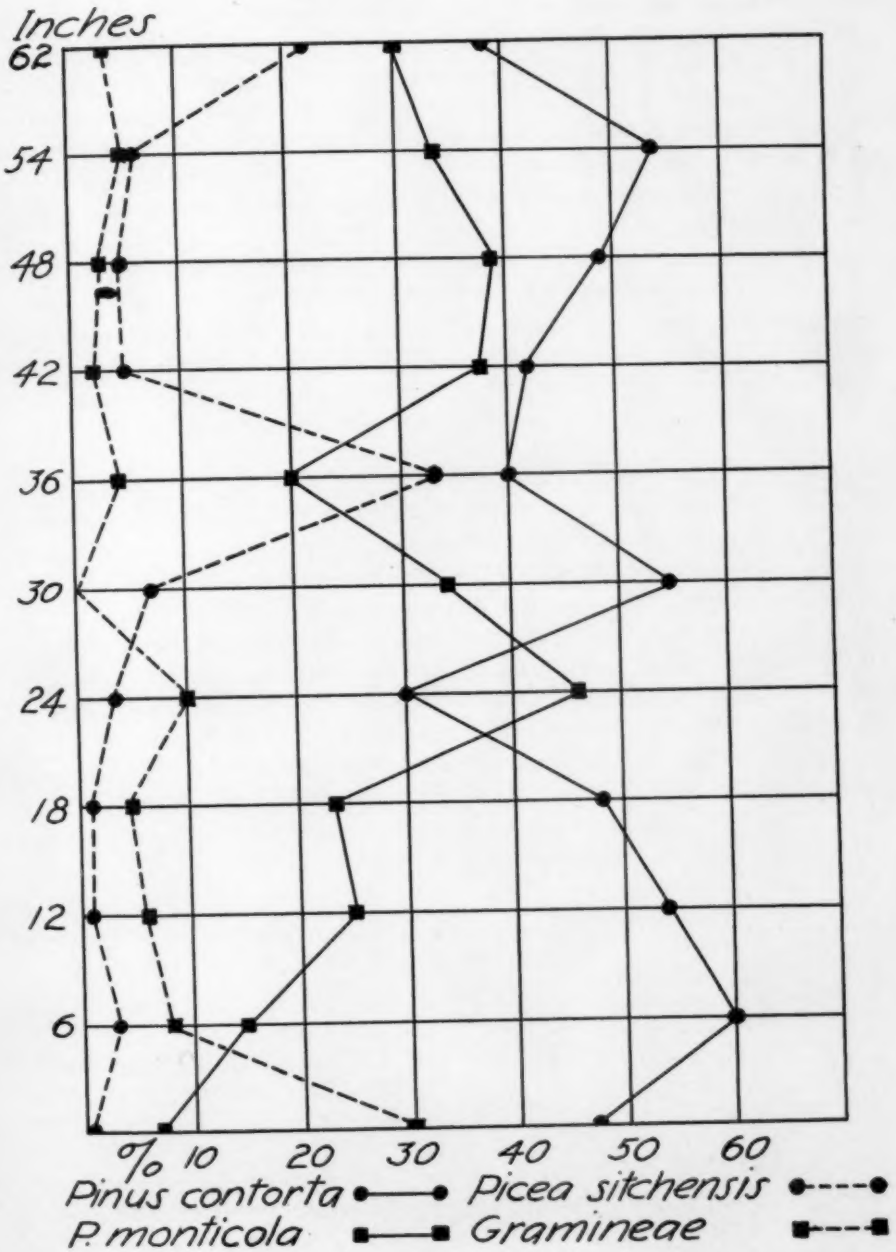


Fig. 2. Pollen diagram.

(table 1), and the absence of sphagnum moss leaves, with the exception of one at the 42 inch horizon, indicate that the bog existed in the sedge stage except when inundated. The greatest number of sedge pollen grains is recorded at 36 inches, the same level at which spruce reaches its maximum. Pollens of other species are present throughout, but not in sufficient numbers to be of importance in the indicated forest succession (table 1). Apparently lodgepole and white pines were dominant during the interval recorded by the peat deposit.

Hemlock, which shows a trace in most of the horizons, may be either western (*Tsuga heterophylla*) or mountain hemlock (*T. mertensiana*). Douglas fir (*Pseudotsuga mucronata*) which played an important part in the postglacial forest succession in the Puget Sound region, seems to be entirely lacking. The dearth of the pollens of these species may be of chronological significance as will be discussed later.

## CHRONOLOGICAL CONSIDERATIONS

The period of time represented by the peat bearing strata is probably short, and represents a relatively small portion of the entire interglacial period. The fact that the peat is strongly compressed would indicate, however, that the time required for its deposition is longer than that for the same thickness of postglacial peat. Lesquereux (1885) estimates that peat in the lower levels of a deposit may be compressed to less than one-eighth of its original volume, but this would depend upon the thickness and composition of the peat. Estimates have been made for the time required for the accumulation of one foot of peat, with considerable differences of opinion by the various investigators (Sears 1933). These estimates range from 2 to 1665 years for peats in various parts of Europe and North America, accumulated under varying conditions. Sears estimates that about 300 years are required for the accumulation of a foot of peat in Ohio. The average depth of nineteen post-Vashon bogs in the Pacific Northwest, shown in a study of their profiles by Rigg (1938), is about 30 feet. This includes the lake mud and sedimentary (limnic) peat, which is taken into consideration here because it contains an abundance of pollen, records pioneer forest succession, and consequently may be used as a time factor. Upon the basis of the above figure, a foot of post-Vashon peat in this region required about 1000 years for its time of accumulation, because it is estimated by geologists that approximately 25,000 to 35,000 years have elapsed since the recession of the Vashon glacier. Considering the amount of compaction caused by its own weight, and that of the overlying sediments, as well as its great age, the peat of this study possibly required about 8000 years for its deposition. The total thickness of the peat itself is about 4 feet, and 2000 years per foot for its rate of accumulation does not seem an unreasonable figure.

As previously shown, the stratigraphic relationships of the peat stratum to the underlying till indicate that its deposition began soon after the retreat of the Admiralty ice from the Seattle area. That forests may exist in close proximity to a glacier is shown by the study of post-Middle Wisconsin forest succession in the driftless area of Wisconsin (Hansen 1939c), and the existence of intraglacial forests in eastern Wisconsin (Wilson 1932). The driftless area was apparently forested during the later stages of the Wisconsin glacial epoch, while forests also existed in eastern Wisconsin during the period of deglaciation between the retreat of the Middle and the advance of the Later Wisconsin ice sheets. Forests actually exist upon certain stagnated Alaska glaciers at present (Washburn 1935), while Cooper (1939), in extensive studies of plant succession in recently deglaciated valleys in Alaska, has shown that forests of spruce and hemlock follow closely in the wake of the receding ice. Climatic and edaphic conditions here may be somewhat similar to those which existed near the ice-front in the Puget Lowland during the Pleistocene. The absence of pollen in the underlying blue clays, silts, and varved clays may indicate the absence of forests until the beginning of the peat deposition.

The stage of forest succession reached at the time of deposition of the uppermost peat may also serve as a chronological criterion by comparison with post-Vashon forest succession. It should be mentioned, however, that forest succession is probably controlled largely by climate, and forest succession, as interpreted from pollen analysis, is one of the few evidences at hand by which one may reach conclusions with respect to interglacial and postglacial climatic fluctuation. As shown by the pollen record, the forests which existed at the beginning of the peat deposition, whether pioneer or later, consisted chiefly of two species which also were dominant in pioneer post-Vashon succession in the Pacific Northwest. As postglacial time in the Puget Sound region progressed, the pioneer species, lodgepole and white pines, were gradually replaced with Douglas fir and hemlock, with the former coming in first and more abundantly (Hansen 1938b). This occurred at a point approximately one-fourth from the bottom in each of two bogs. The time required for the deposition of the lower quarter of peat was perhaps almost one-half of postglacial time, because of the greater compression in the lower levels, and the presence of sedimentary peat, which requires more time for its deposition than a similar thickness of fibrous peat. If this assumption is correct, the replacement of the pioneer species by Douglas fir and hemlock did not occur until almost 15,000 years of post-Vashon time had elapsed. The absence of Douglas fir and the presence of only a trace of hemlock pollen in the peat concerned here indicate that either the climate had not moderated sufficiently for the advent of these species, or the time was too short to have allowed normal

forest succession to have reached that stage. In an interglacial peat stratum underlying the Auburn Delta, ten miles east of Auburn, Washington, both Douglas fir and hemlock pollen was present, as was also that of white fir (*Abies grandis*), white pine, lodgepole pine, and Sitka spruce. White fir and white pine were the dominant species throughout the section, which seems to represent a very brief interval in the upper level of the interglacial stratigraphic sequence (Hansen 1938a).

In a much thicker section of interglacial peats, clays, and silts near Everett, Washington, as high as 40 per cent of hemlock and 15 per cent of Douglas fir pollen was noted in a peat sample about half way up in the section. There is evidence that this section represents a considerable portion of interglacial time, and the presence of an abundance of hemlock and Douglas fir pollen indicates that the forest succession had reached a stage where these species played an important part. It also indicates that the climate was favorable for the existence of these species in the Puget Lowland during the latter half of interglacial time. Thus, the stratigraphic evidence for the peat being of early interglacial origin is further corroborated by pollen analysis, while the forest succession and the thickness of the peat stratum indicate that it represents a period of not over 8000 years duration.

## CLIMATIC CONSIDERATIONS

In terms of climatic interpretation the presence of an abundance of grass, and lodgepole and white pine pollens in the lowest level, marks the existence of a cool and medium dry period during the earliest stage of peat deposition. This appears to have been similar to the early post-Vashon climate in the Puget Sound region, as interpreted from pollen analysis of post-Vashon bogs (Hansen 1938b). The sharp increase of spruce to 33 per cent at the 36 inch horizon apparently marks an increase in humidity and warmth. Its sharp decrease in the succeeding level indicates a recurrence of the earlier cool and medium dry climate, perhaps caused by a minor oscillation or readvance of the Admiralty glacier. A final period of greater humidity and warmth is perhaps reflected by an increase in spruce, and conversely, by a decrease in lodgepole and white pines. The dearth of Douglas fir and hemlock pollens throughout the section indicates that the climate had not moderated sufficiently at the time of termination of the peat deposition to be favorable for the invasion of these species.

## SUMMARY

The geological and stratigraphical relationships of an interglacial peat deposit in Seattle, Washington, indicate that the peat was deposited during the early part of the Puyallup interglacial stage.

Pollen analysis of the peat tends to corroborate the geological evidence, because the initial forests of interglacial time consisted of species similar to those in the same area as well as in other regions in the Pacific Northwest during early post-Vashon time.

The thickness of the peat stratum and the stage of forest succession recorded in the uppermost level, indicate that the interval of time represented by the peat was only a small portion of the interglacial stage, and hypothetically did not extend over more than 8000 years.

In terms of climate, the forest succession suggests four poorly defined alternating periods of coolness and dryness, and warmth and humidity, beginning with the former.

It is fully realized that the age of the peat tends to increase the sources of error which are inherent in pollen statistics, and all conclusions drawn on the basis of pollen analysis may be taken for what they are worth.

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## Literature Cited

**Bretz, J. H.** 1913. Glaciation of the Puget Sound Region. Wash. Geol. Surv. Bull. **8**: 1–244.

**Cooper, W. S.** 1939. A fourth expedition to Glacier Bay, Alaska. Ecol. **20**: 130–156.

**Erdtmann, G.** 1931. Worpswede-Webamum. Ein pollenstatiches Menetekel. Abh. Nat. Ver. Bremen **28**: Sonderhaft.

**Fuller, G. D.** 1935. Postglacial vegetation of the Lake Michigan region. Ecol. **16**: 473–487.

**Hansen, H. P.** 1938a. Pollen analysis of some interglacial peat from Washington. Univ. Wyo. Pub. **5**: 11–18.

————. 1938b. Postglacial forest succession and climate in the Puget Sound region. Ecol. **19**: 528–543.

————. 1939a. Pollen analysis of a bog near Spokane, Washington. Bull. Torr. Bot. Club **66**: 215–221.

————. 1939b. Pollen analysis of a bog in Northern Idaho. Am. Jour. Bot. **26**: 225–229.

————. 1939c. Postglacial vegetation of the driftless area of Wisconsin. Am. Midl. Nat. **21**: 752–763.

**Larsen, J. A.** 1930. Forest types of the Northern Rocky Mountains and their climatic controls. Ecol. **11**: 631–673.

**Lesquereux, L.** 1885. On the vegetable origin of coal. Pa. Geol. Surv. Ann. Rep. Pp. 95–124.

**Rigg, G. B.** 1938. Profiles of some Sphagnum bogs on the Pacific Coast of North America. Ecol. **19**: 408–434.

**Sears, P. B. & E. Janson.** 1933. The rate of peat growth in the Erie Basin. Ecol. **14**: 348–356.

**Washburn, B.** 1935. Conquest of Mt. Crillon. Nat. Geog. Mag. **67**: 361–400.

**Wilson, L. R.** 1932.The Two Creeks forest bed, Manitowoc County, Wisconsin. Trans. Wis. Acad. Arts, Let., Sci. **27**: 31–46.

# New Names and Transfers in the Lobelioideae

ROGERS MCVAUGH

In the course of preparation of monographic studies on the *Campanulaceae*, subfamily *Lobelioideae*, it has been found necessary to make several new combinations and to provide specific names for some species which never have been properly characterized. A list of the new names follows:

1. **Diastatea micrantha** (H. B. K.) comb. nov. *Lobelia micrantha* H. B. K., Nov. Gen. & Sp. 3: 316. 1819 (p. 247 of folio ed.). The genus *Diastatea* was described by Scheidweiler in 1841, and included a single species, *D. virgata*. The original description characterized the genus and species so well that the present writer has no hesitation in stating that *Diastatea virgata* is identical with *Lobelia ramosissima* Mart. & Gal., which was described in 1842. It is, indeed, possible that the plants grown by Scheidweiler at Brussels were from seeds collected by Galeotti in Mexico. Recent studies, soon to be published, indicate that there are six species in Mexico and Central America which form a good natural genus distinct from *Lobelia* and *Laurentia*. The earliest available generic name for these is apparently *Diastatea* Scheidw., Allg. Gartenz. 9: 396. Dec. 1841.

2. **Diastatea tenera** (A. Gray) comb. nov. *Palmerella tenera* A. Gray, Proc. Amer. Acad. 22: 433. 1887. This species is certainly congeneric with the preceding and with *D. virgata*, and belongs neither with *Laurentia* nor to the artificial genus *Palmerella*, the type species of which is to be transferred to *Laurentia*, as indicated below.

3. **Heterotoma cordifolia** (Hook. & Arn.) comb. nov. *Lobelia cordifolia* Hook. & Arn., Bot. Beech. Voy. 301. 1840. This species has passed, for the most part, under the name of *H. tenella* Turcz. Bentham and Hooker recognized the identity of *Lobelia cordifolia* with *Heterotoma tenella*, but, following the so-called "Kew Rule" took up the first combination in the correct genus.

4. **Heterotoma flexuosa** (Presl) comb. nov. *Rapuntium flexuosum* Presl, Prodr. Mon. Lob. 23. 1836. *Lobelia arabidoides* Hook. & Arn., Bot. Beech. Voy. 301. 1840. The TYPE of *Rapuntium flexuosum*, collected in Mexico by Haenke (Herb. Mus. Nat. Pragae 495565) is clearly the plant which has been called *Heterotoma arabidoides*. Presl, oddly enough, failed to note the irregular, spurred calyx of this plant, although he recognized the character as being of generic importance and erected his genus *Myopsia* upon it. The identity of the single species of *Myopsia*, *M. mexicana*, is unknown, although it has usually been considered identical with *Heterotoma lobelioides* Zucc. There is nothing

in Presl's generic description to indicate which species of *Heterotoma* is meant, and Professor Ivan Klásterský states that the type is not to be located at Prague.

5. **Laurentia debilis** (A. Gray) comb. nov. *Palmerella debilis* A. Gray, Proc. Amer. Acad. 11: 80. 1876. The genus *Palmerella* is certainly an artificial one and not to be upheld. This has been recognized by Schönland and others, but the formal combinations under *Laurentia* have apparently never been made.

6. **Laurentia debilis** var. **serrata** (A. Gray) comb. nov. *Palmerella debilis* var. *serrata* A. Gray, Bot. Calif. 1: 619. 1876.

7. **Lobelia stenodonta** (Fern.) comb. nov. *Heterotoma stenodonta* Fern., Proc. Amer. Acad. 36: 504. 1901. A clearly marked species, allied to *Lobelia plebeia* E. Wimm. and to *L. longicaulis* Brandg. There is no indication of any relationship to *Heterotoma*.

8. **Lobelia robusta** Graham, var. **porto-ricensis** (A. DC.) comb. nov. *Tupa assurgens*, var. *porto-ricensis* A. DC., DC. Prodr. 7: 394. 1939. *Lobelia assurgens* L. is confined to Jamaica, with a well-marked variety in central and western Cuba. A similar but quite distinct species, *L. robusta*, is confined to Hispaniola and eastern Cuba, with the present variety known only from Porto Rico.

9. **Lobelia georgiana**, nom. nov. *Lobelia glandulifera* (A. Gray) Small, Fl. S. E. U. S. 1144. 1903, non *L. glandulifera* O. Ktze., Rev. Gen. Pl. 2: 378. 1891. Kuntze's name was a transfer of *Scaevola glandulifera* DC.

10. **Lobelia umbellifera**, nom. nov. *Lobelia fasciculata* Donn. Sm., Bot. Gaz. 27: 338. 1899, non *L. fasciculata* O. Ktze., Rev. Gen. Pl. 2: 378. 1891. Kuntze's name was a transfer of *Scaevola fasciculata* Benth.

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# Additions to Florida Fungi—III

WILLIAM A. MURRILL

(WITH ONE FIGURE)

Numbers here cited refer to specimens in the herbarium of the Florida Agricultural Experiment Station, at Gainesville. My study of the Florida collections of *Marasmius* would have been practically impossible without the generous cooperation of Dr. F. J. Seaver, of the New York Botanical Garden.

## Entoloma Westii sp. nov.

Pileo convexo, umbonato, 3 cm. lato, roseo-avellaneo; sporis angulatis, 10 × 6$\mu$, stipite longo, glabro, albo, 6–8 × 0.2–0.3 cm.

Pileus convex to subexpanded with a sharp conic umbo 3 mm. high, gregarious, 3 cm. broad; surface smooth, glabrous, satiny, rosy-avellaneous, becoming hygrophanous, striate, and dull-vinose; margin projecting 2 mm., entire; context very thin, pallid; lamellae sinuate, broad, medium distant, inserted, entire, pallid to pink; spores angular, usually pentagonal, 1-guttulate, pink, about 10 × 6$\mu$; cystidia none; stipe tapering upward, smooth, glabrous, shining, white, 6–8 × 0.2–0.3 cm.

Type collected by Erdman West on a much-decayed hardwood log in Sugarfoot Hammock, near Gainesville, Fla., Oct. 18, 1938 (*F 18274*). Wood-loving, with a long, slender stipe and a sharp, conic umbo. Very near *E. pinicola* Murrill but without the white incrustations and growing on hardwood instead of pine.

## Russula cystidiosa sp. nov.

Pileo convexo-depresso, 5–7 cm. lato, miniato, striato, sapore grato; sporis spinulosis, ochroleucis, 8–12 × 6–10$\mu$; cystidiis clavatis vel fusoideis, 30–60 × 8–12$\mu$; stipite albo, 7 × 1–2 cm.

Pileus convex to depressed, gregarious, 5–7 cm. broad; surface somewhat viscid, glabrous, uniformly miniatous, peeling readily, margin entire, short-striate; context thin, white, unchanging, odorless, mild; lamellae attenuate behind, equal, not forked, medium broad and medium distant, entire, white to pale-yellow; spores subglobose to broadly ellipsoid, apiculate, spinulose, 1-guttulate, ochroleucous in mass, 8–12 × 6–10$\mu$; cystidia clavate or fusoid, pointed or blunt, hyaline, thin-walled, about 30–60 × 8–12$\mu$; stipe subequal, smooth, glabrous, white, unchanging when dried, about 7 × 1–2 cm.

Type collected by West, Arnold and Murrill under an oak in a high hammock at Sugarfoot, near Gainesville, Fla., Sep. 29, 1938 (*F 18353*).

Related to *R. subrubescens* but uniformly bright-red with milk-white stem.

### Russula mutabilis sp. nov.

Pileo convexo-depresso, 5 cm. lato, viscido, luteo-brunneo ad rubro; sporis spinulosis, 7–8 × 6$\mu$; stipite albo ad rubro, 4 × 1–1.3 cm.

Pileus convex to depressed, gregarious, about 5 cm. broad; surface distinctly viscid, smooth, glabrous, orange-brown, changing to dull-red within an hour after picking, purplish-black when dried; margin more or less striate, not peeling readily; context opaque, juicy, odor slightly like that of *R. foetens* when fresh, like varnish while drying, taste pungent, slightly astringent; lamellae adnate, rather broad, medium distant, forked at the base, entire, pallid or yellowish, reddish when dry; spores subglobose, densely and decidedly spinulose, hyaline under a microscope, 7–8 × 6$\mu$; cystidia none; stipe tapering downward, smooth, glabrous, white, testaceous at the base, soon becoming blood-red below, purple-red when dried, 4 × 1–1.3 cm.

Type collected by West and Murrill on low ground under hardwood trees in Prairie Creek Hammock, southeast of Gainesville, Fla., July 27, 1938 (*F 17943*). When I first saw this plant I thought it was *R. foetens* and started to throw the specimens away, but a red tint on the cap restrained me. When I got to the herbarium the stems were as red as blood on the lower half, with no black. The caps also had deepened to dull-red and later became purplish-black. A determined effort to assign it to Beardslee's *R. rubescens* met with no success.

### Russula subrubescens sp. nov.

Pileo convexo-depresso, 5 cm. lato, viscido, striato, roseo vel roseo-isabellino, sapore grato; sporis spinulosis, ochraceis, 9–11 × 7–8$\mu$; cystidiis fusoideis, 60 × 10$\mu$; stipite albo, 4–5 × 1–1.5 cm.

Pileus convex to deeply depressed, gregarious, 5 cm. broad; surface rather viscid, peeling readily, glabrous, short-striate, roseous, rosy-ochraceous or incarnate-isabelline; context thick, white, unchanging, odorless, mild; lamellae attenuate behind, not forked, equal, medium broad, crowded, entire, white to pale-yellow; spores subglobose to broadly ellipsoid, roughly and densely spinulose, ochroleucous or ochraceous in mass, 1–guttulate, 9–11 × 7–8$\mu$; cystidia abundant, fusiform, pointed, smooth, hyaline, about 60 × 10$\mu$; stipe equal or tapering downward, smooth, glabrous, white, sometimes ochraceous at the base, 4–5 × 1–1.5 cm.

Type collected by West, Arnold and Murrill on the ground under an oak in a high hammock at Sugarfoot, near Gainesville, Fla., Sep. 29, 1938 (*F 18339*). Also at the same time and place (*F 18349*). Suggesting *R. rubescens* Beards. but differing in color and gill structure.

### Melanoleuca albissima floridana var. nov.

Pileo convexo-subexpanso, 6–12 cm. lato, albo, disco cremeo, praefelleo; lamellis albis, sporis globosis, 4$\mu$; stipite albo, 4 $\times$ 0.6–1 cm.

Pileus convex to subexpanded, broadly umbonate at times, scattered to gregarious, 6–12 cm. broad; surface dry, smooth, glabrous, white, with cremeous disk, margin even, entire; context rather tough, drying readily, white, unchanging, with odor of anise, very bitter-farinaceous at once; lamellae adnexed or sinuate with long decurrent tooth, rather narrow, very close, inserted, some forked at the base, entire, white, unchanging; spores globose or nearly so, smooth, hyaline, about 4$\mu$; cystidia none; stipe equal, smooth, glabrous, white, slightly pruinose at the apex, about 4 $\times$ 0.6–1 cm.

Type collected among leaves under hardwoods in Sugarfoot Hammock, near Gainesville, Fla., Oct. 18, 1938 (*F 18287*). Very near *M. albissima* (Peck) Murrill but with more crowded gills and smaller spores. The taste is not at all acrid and the spores appear to be entirely smooth. There is a great resemblance, however, to Peck's species as I remember it. Dried specimens are very light in weight.

### Melanoleuca maculata sp. nov.

Pileo convexo-plano, 9 cm. lato, albo, maculato, felleo; lamellis albis, maculatis, sporis ovoideis, 5 $\times$ 3$\mu$; stipite albo ad citrino, 6 $\times$ 1.2 cm.

Pileus convex to plane, gregarious, 9 cm. broad; surface smooth, glabrous, white with ferruginous spots and stains, margin incurved when young, even, entire, white, becoming lemon-yellow on drying; context white, unchanging, odorless, bitter, sweating profusely in drying; lamellae sinuate or adnexed, broad behind, much crowded, thin, fleshy, white, rusty-spotted, entire, drying slowly with exudation of much water; spores ovoid, smooth, hyaline, about 5 $\times$ 3$\mu$; cystidia none; stipe equal, smooth, finely scurfy, becoming glabrous, milk-white changing to lemon-yellow on drying, 6 $\times$ 1.2 cm.

Type collected by W. A. Murrill on a much-decayed pine log at Sugarfoot, near Gainesville, Fla., Oct. 16, 1938 (*F 18275*). Suggesting *Collybia maculata* but very juicy and partly changing to yellow in drying. The cap goes through a sweating process like a puffball, producing a dried specimen totally distinct from herbarium material of *C. maculata;* while the spores are ovoid instead of subglobose.

### Melanoleuca Westiana sp. nov.

Pileo convexo-plano, 6.5 cm. lato, cremeo, piperato farinaceoque; sporis ellipsoideis, 5–7 $\times$ 3–4$\mu$; stipite albo, 5.5 $\times$ 1.5 cm.

Pileus convex to plane, solitary, 6.5 cm. broad; surface smooth, glabrous, cremeous, margin deflexed, even, entire; context thick, firm, white, unchanging, acrid and farinaceous at once, with anise odor; lamellae sinuate, narrow, medium distant, inserted, undulate, pallid; spores ellipsoid, smooth, hyaline, 1–guttulate, 5–7 × 3–4$\mu$; stipe tapering upward, smooth, pubescent, white, 5.5 × 1.5 cm.

Type collected by Erdman West on the ground under hardwood trees at Boulaware Springs, near Gainesville, Fla., July 17, 1938 (*F 17849*). Near *M. albissima* (Peck) Murrill but of different consistency and not drying white.

### **Prunulus marasmius** sp. nov.

Pileo convexo-expanso, caespitoso, 1–1.5 cm. lato, griseo-albo; lamellis adnatis, albis, sporis ellipsoideis, 4.5 × 3$\mu$; stipite glabro, albo ferrugineoque, 6 × 0.1–0,2 cm.

Pileus convex to expanded, slightly unbilicate at times, densely cespitose, about 1–1.5 cm. broad; surface dry, smooth, glabrous, grayish-white, margin even, entire to rimose; context very thin, white, odorless, slightly astringent; lamellae adnate, narrow, distant, inserted, white to discolored, entire; spores ellipsoid, smooth, hyaline, 1–guttulate, about 4.5 × 3$\mu$; stipe equal, smooth, glabrous, white above, ferruginous below, about 6 × 0.1–0.2 cm.

Type collected by West, Arnold and Murrill on a much-decayed hardwood log in Kelley's Hammock, ten miles northwest of Gainesville, Fla., July 21, 1938 (*F 18277*). Also collected by the same persons at Grove Park, Fla., July 15, 1938 (*F 18270*). Very thin and partially reviving but having the general appearance of *Mycena*.

### **Marasmius caesius** sp. nov.

Pileo convexo, 5–8 mm. lato, pulverulento, caesio vel albo; lamellis adnatis, albis, distantibus; sporis ellipsoideis, 4 × 3$\mu$; stipite pruinoso, albo et murino vel atro, 1–1.5 × 0.1–0.2 cm.

Pileus convex, gregarious, 5–8 mm. broad; surface smooth, pulverulent or finely tomentose, caesious or whitish, fading with age; context membranous, pallid, odorless; lamellae adnate, distant, rather broad, inserted, entire, white, unchanging; spores broadly ellipsoid, smooth, 4 × 3$\mu$; spore-print a mass of stellate, nodulose or irregular bodies 6$\mu$ and more in diameter, some resembling jack-rocks; stipe tapering downward, pruinose, white above, murinous to blackish below, 1–1.5 × 0.1–0.2 cm.

Type collected by W. A. Murrill on fallen oak sticks in a high hammock at Gainesville, Fla., May 28, 1938 (*F 18263*). Also collected by West and Murrill on trash under oaks at the Tung-oil Mill, west of

Gainesville, June 22, 1938 (*F 18358*); and on sticks in oak woods at Gainesville in November, 1932 (*F 9927, F 9935*). The blue color fades quickly and does not appear in dried specimens.

### Marasmius floridanus sp. nov.

Pileo convexo-subexpanso, gregario, 2–3 cm. lato, fulvo; lamellis adnatis, subdistantibus, albis; sporis 6–8 × 2.5–3$\mu$; stipite glabro, albo vel fulvo, 3–7 × 0.2–0.4 cm.

Pileus convex to subexpanded, gregarious, 2–3 cm. broad; surface smooth, glabrous, fulvous; context submembranous, odorless, mild, white; lamellae adnate, inserted, rather narrow, subdistant, entire, white; spores narrowly pip-shaped, smooth, hyaline, 6–8 × 2.5–3$\mu$; stipe equal, smooth, glabrous, shining, white or fulvous, 3–7 × 0.2–0.4 cm.

Type collected by West, Arnold and Murrill on a decayed hardwood log in Planera Hammock, July 16, 1938 (*F 17347*). Also collected several other times on dead wood in hammocks near Gainesville during the summer of 1938 (*F 17719, F 17731, F 17754, F 16388, F 17431*). Very striking and handsome and remaining attractive when dried. Suggesting *M. Berteroi* (Lév.) Murrill, of tropical America, but with much closer gills.

### Marasmius heliomyces sp. nov.

Pileo convexo, 3–4 cm. lato, rugoso, subbadio ad cinereo; lamellis latis, distantibus, albis; stipite glabro, 5–6 × 0.3–0.5 cm.

Pileus hemispheric to broadly convex, not expanding, gregarious or solitary, 3–4 cm. broad; surface glabrous, much wrinkled radially and furrowed, pale-bay when fresh, becoming grayish on drying; margin entire to undulate or rimose; context membranous, white, unchanging, odorless, mild; lamellae sinuate, broad, triangular, distant, inserted, entire, white, unchanging; microscopic examination not satisfactory; stipe equal, hollow, smooth, glabrous, shining, white to bay, about 5–6 × 0.3–0.5 cm.

Type collected by West and Murrill on dead hardwood in Planera Hammock, eleven miles northwest of Gainesville, Fla., Aug. 2, 1938 (*F 18269*). Also collected by E. West on the base of an oak stump at Gainesville, Nov. 1, 1932 (*F 9931*). A rare species suggesting *Heliomyces* and related to *M. Berteroi* (Lév.) Murrill, of tropical America.

### Marasmius nolaneiformis sp. nov.

Pileo convexo-plano, 1.5 cm. lato, striato, umbrino, fibrilloso; sporis ovoideis, 7–8 × 4–5$\mu$, stipite umbrino, 3 × 0.1 cm.

Pileus convex to plane with small umbo, gregarious, about 1.5 cm. broad; surface hygrophanous, zonate, avellaneous and striate on the broad margin, umbrinous over the center and avellaneous on the disk, finely fibrillose-squamulose over the entire surface; context membranous, pallid, odorless, taste nutty; lamellae adnexed, broad, rounded behind, inserted, distant, entire, rosy-isabelline; spores ovoid, smooth, hyaline, granular, 7–8 × 4–5$\mu$; cystidia none; stipe equal, solid, slightly enlarged at the base, pale-umbrinous or isabelline, finely scurfy, about 3 × 0.1 cm.

Type collected by W. A. Murrill in an open lawn at Gainesville, Fla., May 31, 1938 (*F 18259*). Suggesting *Nolanea* but the spore-print is chalk-white.

### Marasmius setulosus sp. nov.

Pileo convexo, umbonato, 1–2 cm. lato, fulvo, hispidulo; lamellis fulvis, spinuliferis, sporis 10–12 × 4–4.5$\mu$; stipite albido badioque, hispidulo, 3–4 × 0.15–0.2 cm.

Pileus convex with broad umbo, gregarious, 1–2 cm. broad; surface smooth, finely hispid, fulvous, darker on the umbo, margin even, entire; context subfleshy, thin, white, odorless, mild to slightly astringent; lamellae adnexed, rounded behind, medium broad, medium distant, inserted, entire, fulvous, unchanging; spores pip-shaped, smooth, hyaline, 1-guttulate, 10–12 × 4–4.5$\mu$; cystidia abundant, pointed, ventricose, hyaline, 45–75 × 5–8$\mu$; stipe equal, smooth, finely hispid, pallid above, bay below, 3–4 × 0.15–0.2 cm.

Type collected by West and Murrill in trash under an oak at Arredonda, Fla., July 29, 1938 (*F 18267*). Also collected by West and Murrill under hardwood trees at Kelley's Hammock, ten miles northwest of Gainesville, Fla., Aug. 3, 1938 (*F 18271*). Suggesting *M. glabellus* Peck but densely covered with fine, straight, sharp, hyaline bristles, while the gills also bristle with long, pointed cystidia. One of the most bristly fungi I ever met.

### Marasmius sicciformis sp. nov.

Pileo conico, 1 cm. lato, sulcato, vinoso; lamellis adnatis, albis; sporis 8 × 5$\mu$, cystidiis 80$\mu$; stipite vinoso, glabro, 3 × 0.1 cm.

Pileus conic, solitary, 1 cm. broad; surface striate-sulcate, glabrous, pale-vinose, darker on the umbo, margin entire; context membranous; lamellae adnate, inserted, broad, medium distant, white, entire; spores broadly ellipsoid, smooth, hyaline, about 8 × 5$\mu$; cystidia few, pointed, tapering from a rather thick base, smooth, hyaline, projecting about 80$\mu$; stipe equal, smooth, glabrous, shining, subconcolorous, hollow, 3 cm. long and less than 1 mm. thick.

Type collected by W. A. Murrill on the ground, probably attached to buried wood, at Gainesville, Fla., April 8, 1938 (*F 16179*). A rare species, beautiful in shape and color, with long, pointed cystidia.

### Marasmius squamosidiscus sp. nov.

Pileo convexo, caespitoso, 3–5 cm. lato, albo, disco ferrugineo-squamuloso; lamellis adnatis, sporis ellipsoideis, 4–5 × 3–3.5$\mu$; stipite squamuloso, albo, 3–4 × 0.3 cm.

Pileus convex, cespitose, 3–5 cm. broad; surface white, the disk decorated with ferruginous scales; margin even, entire to undulate; context subfleshy, thin, white, odorless, sweet and nutty; lamellae adnate, narrow, crowded, inserted, entire, white, unchanging; spores copious, ellipsoid, smooth, hyaline, 4–5 × 3–3.5$\mu$; stipe equal, squamulose, white, unchanging, about 3–4 × 0.3 cm.

Type collected by West, Arnold and Murrill on a much-decayed hardwood log in dry oak-pine woods at Grove Park, Fla., July 15, 1938 (*F 18262*). Suggesting *Collybia maculata* in miniature in coloration but cespitose and scaly.

### Marasmius subarchyropus sp. nov.

Pileo convexo-plano 4–6 cm. lato, pallido; lamellis albis, sporis ellipsoideis, 5–6 × 3–4$\mu$; stipite pallido, pruinoso, 6–9 × 0.4–0.8 cm.

Pileus convex to plane or depressed, gregarious, 4–6 cm. broad; surface smooth, glabrous, pallid, pale-yellowish when dry; context subfleshy, white, odorless; lamellae adnexed, or adnate with a decurrent tooth, very crowded, very narrow, inserted, entire, white; spores ellipsoid, smooth, hyaline, 5–6 × 3–4$\mu$; cystidia none; stipe equal, ridged at the apex, pallid, pruinose to subglabrous, 6–9 × 0.4–0.8 cm.

Type collected by West and Murrill on much-decayed hardwood in Planera Hammock, eleven miles northwest of Gainesville, Fla., July 20, 1938 (*F 18264*). Resembling *M. archyropus* (Pers.) Fries but much larger and with different spores.

### Marasmius subgraminis sp. nov. Fig. 1

Pileo convexo-expanso, 4–8 mm. lato, albo; lamellis adnatis, distantibus; sporis 7–9 × 3–4$\mu$; stipite glabro, pallido, 5–10 × 0.5–1 mm.

Pileus membranous, convex to very slightly depressed, neither umbonate nor umbilicate, densely gregarious to cespitose, 4–8 mm. broad; surface dry, glabrous, not shining, white or slightly stramineous, margin undulate, sometimes rimose, slightly sulcate with age, deflexed on drying; context very thin, white, odor agreeable, taste slightly astringent; lamellae squarely adnate,

Fig. 1. Marasmius subgraminis Murrill. ×2.—*Photo by G. F. Weber.*

without a collar, plane, rather broad, distant, slightly interveined, several times inserted, entire on the edges, pallid to isabelline; spores pip-shaped, smooth, hyaline, not consistently guttulate, about 7–9 × 3–4$\mu$; stipe lumpy, usually much enlarged and finely striate at the apex, white above and slightly rosy-avellaneous below, glabrous, 5–10 × 0.5–1 mm.

Type collected by Dr. George F. Weber on dead centipede grass on his lawn in Gainesville, Fla., Oct. 5, 1938 (F *18361*). Related to *M. graminis* Murrill, which was discovered on dead Bermuda grass on lawns in Cuba. The spores were found and studied by Dr. Weber after fruitless efforts on my part. The photograph reproduced herewith was taken by him.

### Marasmius subnigricans sp. nov.

Pileo convexo, gregario, 1.5–3 cm. lato, albo, subnigricante; lamellis adnatis, distantibus, albis, subnigricantis; sporis 8–10 × 3–4$\mu$, cystidiis 30 × 10–15$\mu$, stipite albo, 3–4 × 0.2–0.3 cm.

Pileus campanulate to broadly convex, often umbonate, gregarious, 1.5–3 cm. broad; surface smooth or rugose, glabrous, pure-white, usually becoming partly or wholly blackish on drying; margin entire to undulate, even or sulcate-striate; context membranous, white, changing to blackish, odorless, mild;

lamellae squarely adnate, narrow, distant, inserted, interveined, entire, white, becoming blackish; spores narrowly pip-shaped, smooth, hyaline, 8–10 × 3–4μ; cystidia abundant, bottle-shaped, usually abruptly pointed, hyaline, projecting about 30 × 10–15μ; stipe equal, smooth, glabrous, white, unchanging or darkening slightly when dried, about 3–4 × 0.2–0.3 cm.

Type collected by W. A. Murrill on hardwood sticks in a high hammock at Gainesville, Fla., July 1, 1938 (*F 17358*). Very common about Gainesville on fallen hardwood sticks, especially on oak (*F 17359*, *F 16324*, *F 9925*, *F 9937*, *F 9938*). Rather surprising in its change from pure-white to almost black. *M. nigripes* (Schw.) Fries is described as having angular spores and a black, horny stem.

### Marasmius subprasiosmus sp. nov.

Pileo convexo, gregario, 2–3 cm. lato, sulcato, cremeo, alliaceo; sporis 5 × 2.5μ, stipite albo, pruinoso, 3–4 × 0.2 cm.

Pileus convex to subexpanded, slightly umbilicate at times, gregarious to subcespitose, 2–3 cm. broad; surface glabrous, radiate-sulcate, cremeous with a fulvous tint, the disk pale-fulvous; context tough, membranous, odor slight but distinctly alliaceous, taste mucilaginous and alliaceous; lamellae adnexed, narrow, unequal, distant, entire, white; spores subfusiform, smooth, hyaline, about 5 × 2.5μ; cystidia none; stipe enlarged below, smooth, pruinose, white, about 3–4 × 0.2 cm.

Type collected by W. A. Murrill on a lawn in Gainesville, Fla., May 31, 1938 (*F 18362*). Strongly suggestive of *M. prasiosmus* Fries in some of its characters.

### Marasmius substenophyllus sp. nov.

Pileo convexo-subexpanso, 1.5–2.5 cm. lato, albo, glabro; lamellis decurrentibus, albis, sporis ellipsoideis, 6 × 4μ; cystidiis clavatis, 20–45 × 6–8μ; stipite albo, glabro, 1.5–3 × 0.2–0.3 cm.

Pileus convex to subexpanded, gregarious, 1.5–2.5 cm. broad; surface dry, smooth, white, glabrous, margin even, entire; context subfleshy, thin, white, odorless, slightly bitter; lamellae decurrent, inserted, distant, rather narrow, entire, white; spores copious, ellipsoid, smooth, hyaline, 1-guttulate, about 6 × 4μ; cystidia abundant, smooth, hyaline, usually clavate, projecting 20–45 × 6–8μ; stipe subequal, smooth, white, glabrous, with a white disk at the base, about 1.5–3 × 0.2–0.3 cm.

Type collected by West, Arnold and Murrill on dead hardwood in Planera Hammock, eleven miles northwest of Gainesville, Fla., July 21, 1938 (*F 18268*). Also collected by West and Murrill in Sanchez Ham-

mock, July 23, 1938 (*F 18272, F 18276*). Reminding one of the common tropical species, *M. stenophyllus*, but thicker, more fleshy, and white throughout.

### Marasmius subsynodicus sp. nov.

Pileo membranaceo, convexo-plano, gregario, 5–7 mm. lato, pallido; lamellis adnatis, distantibus, albis; sporis ovoideis, 4–5 × 2$\mu$; stipite albo vel pallido, 5–10 × 0.5 mm.

Pileus membranous, convex to plane or slightly depressed, gregarious to subcespitose, 5–7 mm. broad; surface smooth, finely pulverulent under a lens, pale-isabelline to white, margin entire, even; context very thin, white, mild, odorless; lamellae adnate with a slight decurrent tooth, broad, distant, inserted, white, stramineous when dry, entire; spores few, oblong-ovoid, smooth, hyaline, about 4–5 × 2$\mu$; stipe equal, smooth, finely fibrillose, white above, pallid with a rosy tint below, 5–10 × 0.5 mm.

Type collected by W. A. Murrill on chips and sticks in a pine grove at Gainesville, Fla., Oct. 21, 1932 (*F 9932*). Also collected by Dr. G. F. Weber on dead grass on a lawn in Gainesville, Oct. 2, 1938 (*F 18356*). Related to *M. synodicus* (Kunze) Fries. It is a small white species, densely gregarious and plentiful.

#### NEW COMBINATIONS

For those using Saccardo's nomenclature the following new combinations are made:

*Melanoleuca maculata* = **Tricholoma maculatum**
*Melanoleuca Westii* = **Tricholoma Westiana**
*Prunulus marasmius* = **Mycena marasmius**

HERBARIUM FLORIDA AGRICULTURAL EXPERIMENT STATION
GAINESVILLE, FLORIDA

# Development of the Embryo-sac of Gagea fascicularis Salisb.

A. C. Joshi

(with 11 figures)

The development of the embryo-sac of *Gagea fascicularis* Salisb. (*G. lutea* Ker-Gawl.) was studied by Stenar (1927), and he described it to correspond to the *Lilium*-type, now called the *Adoxa*-type, with the modification that one of the chalazal nuclei of the 4-nucleate embryo-sac did not undergo the third division and the mature embryo-sac therefore possessed only two antipodals. The recent investigations of *Gagea ova*, *G. graminifolia* and *G. tenera* by Romanov (1936) and *G. minima* by Westergård (1936), on the other hand, have shown that the development of the embryo-sac in all these species corresponds to the *Fritillaria*-type. The development of the embryo-sac of *Gagea fascicularis*, therefore, needs reinvestigation.

The material used in the investigation was collected by me from Khilanmarg in the Kashmir State. Plants of *Gagea fascicularis* grow here at a height of 8000 to 13,000 feet. They flower mostly during the month of May, but a few flowers could still be seen at higher elevations about the 20th of June, 1938, when I visited this locality, and these were collected. They were fixed in Navashin's fluid and studied according to the customary methods. A few stages were found to be missing in this material, but fortunately these are sketched by Stenar (1927), and by considering them along with the stages present in my own preparations it has been possible to complete the series.

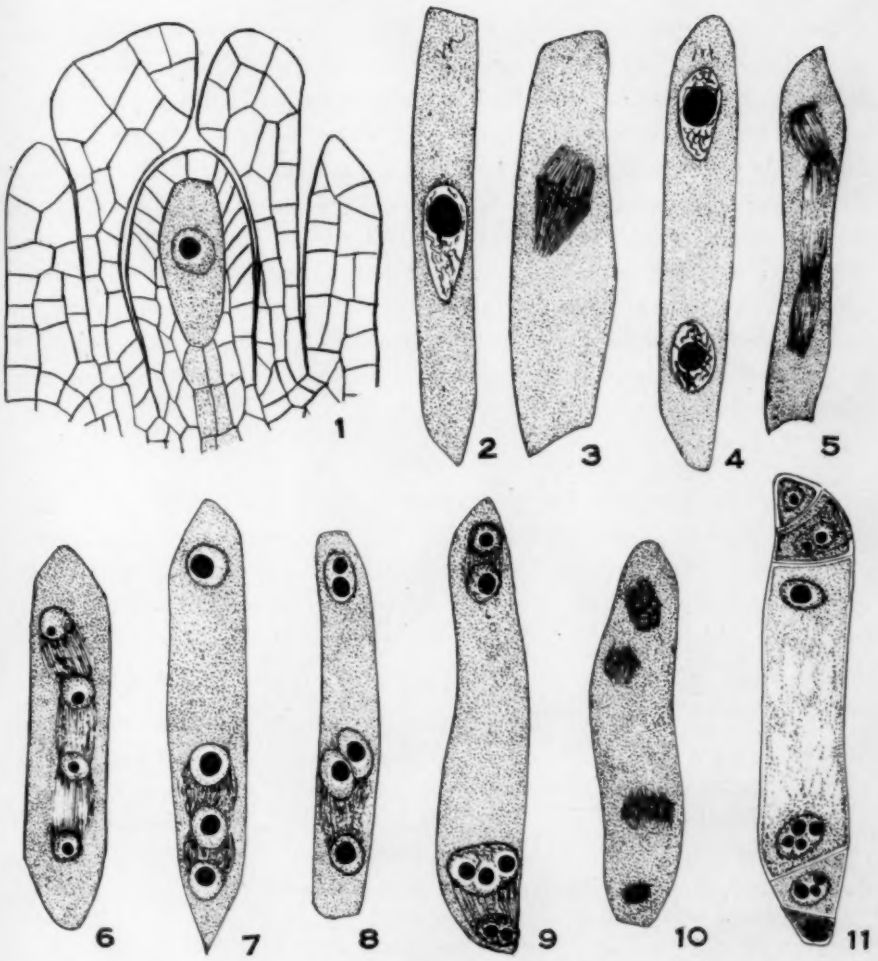
## Observations

The ovary is trilocular and there are two rows of ovules in each loculus except in the upper portion. Here the ovules form only one row. They are anatropous and bitegmic. The outer integument is three cells thick, while the inner is mostly two cells thick except in the micropylar region, where it is thicker. The micropyle is formed only by the inner integument. The nucellus is poorly developed (Fig. 1). About two rows of central cells in the chalazal region of the nucellus have denser cytoplasm than the rest. These connect the chalazal end of the embryo-sac with the vascular bundle of the ovule which ends in the chalaza and probably help in the transmission of food materials from the vascular bundle to the embryo-sac.

The archesporium is hypodermal and is mostly limited to one cell (Fig. 1). Stenar (1927) observed two or three archesporial cells in exceptional cases, but I did not come across any such in the present material. No parietal cell is cut off and the primary archesporial cell directly becomes the megaspore-mother cells.

The megaspore-mother cell stage is of very long duration. The ovules remain at this stage till the flowers open and the anthers dehisce. After this the development of the embryo-sac is very rapid and all stages from the megaspore-mother cell to the mature embryo-sac may be seen in the same ovary. As the material was collected from a far off place, it has not been possible to determine if further development of the embryo-sac from the megaspore-mother cell stage is conditioned by previous pollination. It is however quite possible that such a relation may exist and the embryo-sac may begin to develop in the ovules only after the flower has been pollinated. It is well known that in the Orchidaceae ovules do not develop until pollination of the flower occurs. *Gagea fascicularis* shows a comparatively primitive stage from which this highly specialized behavior of the Orchidaceae could have evolved.

The first division of the nucleus of the megaspore-mother cell, which is the reduction division, is not followed by any wall formation and results in the development of a 2-nucleate embryo-sac (Figs. 2–4). The next division leads to the development of the 4-nucleate embryo-sac. During this division as the daughter nuclei reach the telophase stage, the homotypic spindles become connected by secondary spindle fibres (Figs. 5 and 6). These spindle fibres are a new development as described by Stenar (1927) and not the remnants of the heterotypic spindle as believed by Schaffner (1897) and Coulter and Chamberlain (1903) from their studies of *Lilium*, because no such spindle fibres are seen at the 2-nucleate embryo-sac stage (Fig. 4). The nuclei in the 4-nucleate embryo-sac are at first nearly uniformly distributed (Fig. 6). Later the spindle fibres between the two micropylar nuclei disappear, while the other two spindles contract. The result is that one nucleus is left at the micropylar end of the embryo-sac and the remaining three are drawn toward the chalazal end (Figs. 7 and 8). During the next division of the nuclei the three chalazal nuclei fuse and a new 4-nucleate embryo-sac arises with two small nuclei at the micropylar end and two large nuclei at the chalazal end (Fig. 9). The number of nucleoli shows that the chalazal nuclei are triploid. One more division of the nuclei occurs to complete the development of the embryo-sac (Fig. 10), but during this division one of the




**Gagea fascicularis** Salisb.

Fig. 1. Part of a longitudinal section of an ovule at an early megaspore-mother cell stage showing the structure of the integuments and the nucellus.

Figs. 2–3. Megaspore-mother cell, heterotypic division, prophase and metaphase.

Fig. 4. 2-nucleate embryo-sac.

Figs. 5–6. Two stages in the development of the 4-nucleate embryo-sac.

Figs. 7–8. 4-nucleate embryo-sacs showing 1 + 3 arrangement of the megaspore nuclei.

Fig. 9. A secondary 4-nucleate embryo-sac.

Fig. 10. The fourth nuclear division in the development of the embryo-sac.

Fig. 11. 7-nucleate embryo-sac.

Figs. 2, 5 and 10 after Stenar (1927), the rest original. Fig. 1, ×300; Figs. 2–11, ×700.

chalazal nuclei fails to divide. It begins to degenerate. The embryo-sac is thus ultimately only 7-nucleate (Fig. 11). There is a normal egg-

apparatus, a haploid micropylar polar nucleus and triploid chalazal polar nucleus and two antipodals, out of which the chalazal antipodal is in a degenerating condition from the very beginning of its differentiation.

It is thus clear that in *Gagea fascicularis* in the development of the 7-nucleate embryo-sac from the megaspore-mother cell four nuclear divisions occur. The megaspore nuclei show 1+3 arrangement. During the third nuclear division the three chalazal nuclei fuse giving rise to a secondary 4-nucleate stage with larger triploid chalazal nuclei, as Bambacioni (1928) has shown in *Fritillaria persica* and Cooper (1935) in *Lilium Henryi*. The development of the embryo-sac, therefore, corresponds to the *Fritillaria-type*, as in species of *Gagea* investigated by Romanov (1936) and Westergård (1936).

SUMMARY

The ovules remain at the megaspore-mother cell stage until the anthesis of the flowers. No parietal cell is cut off. The primary archesporial cell directly develops into the megaspore-mother cell and later into the embryo-sac. The development of the embryo-sac corresponds to the *Fritillaria-type* with the modification that one of the chalazal nuclei after the second 4-nucleate stage does not divide and the complete embryo-sac is only 7-nucleate and 6-celled.

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## Literature Cited

**Bambacioni, V.** 1928. Ricerche sulla ecologia e sulla embriologia di *Fritillaria persica* L. Ann. Bot., Roma **18**: 7–37.

**Cooper, D. C.** 1935. Macrosporogenesis and development of the embryo sac of *Lilium Henryi*. Bot. Gaz. **97**: 346–355.

**Coulter, J. M., and Chamberlain, J. C.** 1903. Morphology of angiosperms. New York.

**Romanov, I. D.** 1936. Die Embryosackentwicklung in der Gattung *Gagea* Salisb. Planta **25**: 438–459.

**Schaffner, J. H.** 1897. Contribution to the life history of *Lilium philadelphicum*. III. The division of the macrospore nucleus. Bot. Gaz. **23**: 430–452.

**Stenar, H.** 1927. Ueber die Entwicklung des siebenkernigen Embryosackes bei *Gagea lutea* Ker. nebst einigen Bemerkungen über die Reduktionteilung bei *Gagea minima* Ker. Svensk Bot. Tidsk. **21**: 344–360.

**Westergård, M.** A cytological study of *Gagea spathacea* with a note on the chromosome number and embryo-sac formation in *Gagea minima*. C. R. Trav. Lab. Carlsberg, Sér. Phys. **21**: 437–451.

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**Ark, P. A. & Tompkins, C. M.** Bacteriosis of tuberous begonia. Phytopathology **29**: 633–637. *f. 1, 2.* Jl 1939.

**Arnon, D. I. & Stout, P. R.** Molybdenum as an essential element for higher plants. Plant. Physiol. **14**: 599–602. *f. 1.* Jl 1939.

**Baines, R. C.** Phytophthora trunk canker or collar rot of apple trees. Jour. Agr. Res. **59**: 159–184. *pl. 1.+f. 1–4.* 1 Au 1939.

**Barkley, F. A. & Reed, M. J.** Studies in the Anacardiaceae—IV. Am. Midl. Nat. **22**: 209–211. *pl. 1.+f. 1.* Jl 1939.

**Barton, L. V.** Storage of some flower seeds. Contr. Boyce Thompson Inst. **10**: 399–427. *f. 1–7.* Jl-S 1939.

**Bartram, E. B.** Mosses of the Philippines. Philippine Jour. Sci. **68**: 1–437. *pl. 1–29.* Ja-Ap 1939.

**Bates, J. C.** Effects of certain alkaloids on the growth of *Aspergillus niger* and *Rhizopus nigricans*. Univ. Kansas Sci. Bull. **25**: 85–112. *f. 1–3.* 1 Je 1938.

**Bauer, B.** Check list of the flowering plants of Missouri. *mimeog. map + illust.* Webster Grove, Mo.

**Beadle, G. W.** Teosinte and the origin of maize. Jour. Heredity **30**: 245–247. *f. 8.* Je 1939.

**Bean, W. J.** Deciduous American oaks. New Flora & Silva **11**: 248–253. Jl 1939.

**Becker, C. L.** Inheritance studies in the interspecific cross *Solanum demissum* Lindl. × *S. tuberosum* L. Jour. Agr. Res. **59**: 23–39. 1 Jl 1939.

**Benedict, R. C.** Growing ferns from spores. Am. Fern Jour. **29**: 95–98. *illust.* Jl-S 1939.

**Benke, H. C.** New color form in South Dakota aster. Am. Midl. Nat. **22**: 212, 213. Jl 1939.

**Berry, E. W.** Fossil plants from the Cretaceous of Minnesota. Jour. Washington Acad. Sci. **29**: 331–336. *f. 1–4.* 15 Au 1939.

**Blood, H. L. & Watson, R. D.** A modification of the tobacco mosaic virus No. 1 occurring in *Datura meteloides*. Utah Acad. Sci. Art and Letters **15**: 15–19. 1938.

**Brink, R. A., Keller, W. & Eisenhart, C.** Differential survival of alfalfa strains under an ice sheet. Jour. Agr. Res. **59**: 59–71. *f. 1–4*. 1 Jl 1939.

**Burkart, A.** Catálogo de las especies de Adesmia conocidas de la flora Argentina. Darwiniana **3**: 303–346. 1939.

**Burkart, A.** El nombre cientifico del "caldén" de La Pampa (*Prosopis caldenia*, nov. spec.). Darwiniana **3**: 111–115. *pl. 1, 2*. 1939.

**Burkart, A.** Estudios sistematicos sobre las Leguminosas-Hedisareas de la Republica Artentina y regiones adyacentes. Darwiniana **3**: 117–302. *pl. 1–22.+f. 1–19*. 1939.

**Burrell, R. C. & Miller, H. A.** The vitamin C content of spring greens. Science **90**: 164, 165. 18 Au 1939.

**Cabrera, A. L.** Notas sobre los Senecio Sudamericanos. Inst. Mus. Nac. La Plata **4**: 1–113. *pl. 1–5.+f. 1–14*. 1939.

**Chamberlain, G. D.** *Ranunculus lapponicus* in Aroostook County, Maine. Rhodora **41**: 461. S 1939.

**Chang, S. C.** The transformation of phosphorus during the decomposition of plant materials. Soil Sci. **48**: 85–99. *f. 1*. Au 1939.

**Clute, W. N.** Meaning of plant names. LXXIX. Lindens and grapes. Am. Bot. **45**: 111–115. Jl 1939.

**Cochran, H. L.** Growth and distribution of roots of the Perfection pimiento in Georgia. Jour. Agr. Res. **59**: 185–197. *f. 1–14*. 1 Au 1939.

**Conzatti, C.** Flora taxonómica Mexicana **1**[1]: 145–167. 1939.

**Cook, O. F. & Doyle, C. B.** The edible pacaya palm of Alta Vera Paz. Nat. Hort. Mag. **18**: 161–179. *f. 1–9*. Jl 1939.

**Cooke, W. B.** Some ferns of Mount Shasta. Am. Fern Jour. **29**: 105–111. Jl-S 1939.

**Correll, D. S.** Some fern notes. Am. Fern Jour. **29**: 102–105. Jl-S 1939.

**Cottam, C.** The eelgrass situation on the American Pacific coast. Rhodora **41**: 257–260. Jl 1939.

**Crafts, A. S.** Movement of viruses, auxins, and chemical indicators in plants. Bot. Rev. **5**: 471–504. S 1939.

**Croizat, L.** An interpretation of *Euphorbia edulis* Loureiro. Philippine Jour. Sci. **69**: 287–296. Jl 1939.

**Darlington, H. T. & Culver, L. B.** Keys to the species of *Ribes* occurring in the Great Lakes region. Michigan State Coll. Agr. Exp. Sta. Circ. Bull. 170: 1–24. *f. 1–13*. Je 1939.

**Darrah, W. C.** The fossil flora of Iowa coal balls. II. The fructification of *Botryopteris*. Harvard Univ. Bot. Mus. Leafl. **7**: 157–180. *pl. 1–6*. 6 S 1939.

**Daubenmire, R. F.** Range extensions for southeastern Washington and adjacent Idaho. Leafl. West. Bot. **11**: 199, 200. Jl 1939.

**Denny, F. E.** Respiration of gladiolus corms during prolonged dormancy. Contr. Boyce Thompson Inst. **10**: 453–460. *f. 1, 2*. Jl-S 1939.

**Dix, W. L.** Observations on Botrychiums. Am. Fern Jour. **29**: 112, 113. Jl-S 1939.

**Doell, J. H.** The flora of the Sand Hills of Harvey County, Kansas. Kansas Sci. Bull. **25**: 113–147. *pl. 13–18*+*f. 1–4*. 1 Je 1938.

**Drew, W. B.** A new record of *Fissidens sublimatus*. Bryologist **42**: 112. Au 1939.

**Dundas, B. & Scott, G. W.** Physiologic strains of bean rust. Phytopathology **29**: 820, 821. S 1939.

**Eastwood, A.** *Lupinus Danaus* on Mt. Dana and at adjacent localities. Leafl. West. Bot. **11**: 201, 202. Jl 1939.

**Eastwood, A.** Some undescribed northern California *Valeriana*. Leafl. West. Bot. **11**: 196–199. *f. 1–4*. Jl 1939.

**Enzie, W. D.** Yellow sweet corn hybrids for New York. New York State Agr. Exp. Sta. Bull. 686: 1–59. *pl. 1–4*. Jl 1939.

**Epling, C. & Stewart, W. S.** A revision of *Hedeoma* with a review of allied genera. Repert. Spec. Nov. Beih. **115**: 1–49. *pl. 1–3*.+*map 1–4*. 1939.

**Everett, T. H.** Beaux of the Begonia clan. Real Gard. **2**: 57–63. *illust*. S 1939.

**Everett, T. H.** Plant portraits. Gard. Chron. Am. **43**: 285, 286. *illust*. S 1939.

**Ewan, J.** *Centranthus:* a new immigrant genus to California. Leafl. West. Bot. **11**: 195. Jl 1939.

**Ewan, J.** Review of the genus *Githopsis*. Rhodora **41**: 302–313. *pl. 555*. Jl 1939.

**Fassett, N. C.** Notes from the herbarium of the University of Wisconsin—XVII. *Elatine* and other aquatics. Rhodora **41**: 367–377. *f. 1–4*.+*maps*. Au 1939.

**Fernald, M. L.** New species, varieties and transfers. Rhodora **41**: 423–461. *pl. 559–569*. S 1939.

**Fischer, G. W.** Studies on the susceptibility of forage grasses to cereal smut fungi. III. Further data concerning *Tilletia levis* and *T. tritici*. Phytopathology **29**: 575–591. *f. 1, 2*. Jl 1939.

**Forbes, I. L.** Factors affecting the development of *Puccinia coronata* in Louisiana. Phytopathology **29**: 659–684. Au 1939.

**Franzke, C. J., Puhr, L. F. & Hume, A. N.** A study of sorghum with reference to the content of HCN. South Dakota State Coll. Agr. Exp. Sta. Tech. Bull. 1: 1–51. *f. 1–6.* Ap 1939.

**Frye, E. M.** We go to Mexico. New Flora and Silva **11:** 269–275. *f. 88–92.* Jl 1939.

**Frye, T. C. & Clark, L.** Hepaticae of North America. Univ. Washington Publ. Biol. $6^1$: 1–162. *illust.* N 1937.

**Gifford, J. C.** Lignum-vitae, the tree of life. Sci. Monthly **49:** 30–32. *illust.* Jl 1939.

**Gojdics, M.** Some observations on *Euglena sanguinea* Ehrbg. Trans. Am. Micro. Soc. **58:** 241–248. *pl. 1.* Jl 1939.

**Goldsworthy, M. C. & Green, E. L.** The fungicidal activity of phenothiazine and some of its oxidation derivatives. Phytopathology **29:** 700–716. *f. 1.* Au 1939.

**Goodman, G. J.** A new species of *Chorizanthe.* Leafl. West. Bot. **11:** 193–195. Jl 1939.

**Gottlieb, M. & Butler, K. D.** A pythium root rot of cucurbits. Phytopathology **29:** 624–628. *f. 1.* Jl 1939.

**Grace, N. H.** Effect of plant and animal hormones on the rooting of dust and solution-treated dormant stem cuttings. Canadian Jour. Res. **17:** 305–311. S 1939.

**Grace, N. H.** Vegetative propagation of conifers. II. Effects of nutrient solution and phytohormone dusts on the rooting of Norway spruce cuttings. Canadian Jour. Res. **17:** 312–316. S 1939.

**Grout, A. J.** Moss flora of North America, north of Mexico. $1^4$: 193–264. *pl. 91–129.* Jl 1939.

**Gundersen, A.** The classification of dicotyledons. Torreya **39:** 108–110. Jl-Au 1939.

**Hahn, G. G.** Susceptibility of seedlings of *Ribes punctatum,* an Andine Currant, to *Cronartium ribicola.* Phytopathology **29:** 643, 644. Jl 1939.

**Hara, H.** Some notes on the botanical relation between North America and eastern Asia. Rhodora **41:** 385–392. S 1939.

**Herre, A. W.** A new species of lichen from North Carolina. Bryologist **42:** 109. Au 1939.

**Hewitt, W. B.** Leaf-scar infection in relation to the olive knot disease. Hilgardia **12:** 41–65. *pl. 1–5.*+*f. 1–5.* O 1938.

**Hill, A. F.** The correct names of certain economic plants. Harvard Univ. Bot. Mus. Leafl. **7:** 89–112. 19 Je 1939.

**Hirschhorn, E.** Las especies del género Ustilago en la Argentina. Darwiniana **3:** 347–418. *pl. 1–6.*+*f. 1–6.* 1939.

**Hitchcock, A. E. & Zimmerman, P. W.** Unusual physiological responses induced on intact plants by capping with black cloth. Contr. Boyce Thompson Inst. **10:** 389–398. *f. 1, 2.* Jl-S 1939.

**Hitchcock, A. S., Swallen, J. R. & Chace, A.** North American flora. (Poales) Poaceae. N. Y. Bot. Gard. **17:** 543–638. 14 Jl 1939.

**Hopkins, J. W.** Estimation of leaf area in wheat from linear dimensions. Canadian Jour. Res. **17:** 300–304. *f. 1.* S 1939.

**Hotson, J. W.** Key to the rusts of the Pacific northwest. Univ. Washington Publ. Biol. **3:** 1–193. N 1934.

**Howell, J. T.** Studies in *Ceanothus*—II. Leafl. West. Bot. **11:** 202–208. Jl 1939.

**Hume, A. N. & Franzke, C. J.** The germination of seed corn and its relation to the occurrence of molds during germination. South Dakota State Coll. Agr. Exp. Sta. Bull. 275: 1–19. *f. 1–7.* F 1933.

**Jennison, H. M.** Flora of the Great Smokies. Jour. Tennessee Acad. Sci. **14:** 266–298. *f. 1–26.* Jl 1939.

**Johnson, E. L.** A wild double strawberry from Colorado. Torreya **39:** 112, 113. Jl-Au 1939.

**Jones, G. N.** The flowering plants and ferns of Mount Rainier. Univ. Washington Publ. Biol. **7:** 1—192. *pl. 1–9.* D 1938.

**Keitt, G. W. & Clayton, C. N.** A destructive bud-transmissible disease of sour cherry in Wisconsin. Phytopathology **29:** 821, 822. S 1939.

**Kirkpatrick, H.** Root-inducing substances as an aid in propagating dahlias. Bull. Am. Dahlia Soc. **14:** 9–11. Au 1939.

**Koehler, B.** Crazy top of corn. Phytopathology **29:** 817–820. *f. 1.* S 1939.

**Korstian, C. F. & Coile, T. S.** Plant competition in forest stands. Duke Univ. School Forestry Bull. **3:** 1–125. *f. 1–71.* N 1938.

**Kreutzer, W. A.** Host parasite relationships in pink root of *Allium cepa* L. I. The pigment of *Phoma terrestris.* Phytopathology **29:** 629–632. Jl 1939.

**Krotkov, G.** Carbohydrate and respiratory metabolism in the isolated starving wheat leaf. Plant Physiol. **14:** 203–226. *f. 1–12.* Ap 1939.

**Krotkov, G.** Carbohydrates of wheat leaves. Plant Physiol. **14:** 559–565. Jl 1939.

**Kunkel, L. O.** Movement of tobacco-mosaic virus in tomato plants. Phytopathology **29:** 684–700. *f. 1, 2.* Au 1939.

**Lackey, J. B.** Notes on plankton flagellates from the Scioto River. Lloydia **2:** 128–143. *f. 1–38.* Je 1939.

**LeClerg, E. L.** Methods of determination of physiologic races of *Rhizoctonia solani* on the basis of parasitism on several crop plants. Phytopathology **29**: 609–616. *f. 1.* Jl 1939.

**LeClerg, E. L.** Relative efficiency of quasi-factorial and randomized-block designs of experiments concerned with damping-off of sugar beets. Phytopathology **29**: 637–641. Jl 1939.

**LeClerg, E. L.** Studies on dry-rot canker of sugar beets. Phytopathology **29**: 793–800. *f. 1. 2.* S 1939.

**Leggatt, C. W.** Statistical aspects of seed analysis. Bot. Rev. **5**: 505–529. S 1939.

**Leonian, L. H. & Lilly, V. G.** Studies in the nutrition of fungi. II. Effect of inoculum on the growth of the colony. Phytopathology **29**: 592–596. *f. 1, 2.* Jl. 1939.

**Lichtenstein, J. S. de.** Las especies argentinas del género *Salvinia*. Darwiniana **3**: 93–110. *f. 1, 2.* 1939.

**Linford, M. B. & Yap, F.** Root-knot nematode injury restricted by a fungus. Phytopathology **29**: 596–609. *f. 1.* Jl 1939.

**Lowe, R. L.** A list of Maine mosses in the herbarium of the Portland Society of Natural History. Bull. Josselyn Bot. Soc. **7**: 60–67. 1939.

**Luetzelburg, P. von.** Die pflanzengeographischen Verhältnisse im Amazonas-Gebiet. Ber. Deutsch. Bot. Gesell. **57**: 247–262. *pl. 6–11.* 1939.

**Lundell, C. L.** Revision of the American Celastraceae I. *Wimmeria, Microtropis,* and *Zinowiewia*. Contr. Univ. Michigan Herb. No. 3: 1–46. *pl. 1–10.* Jl 1939.

**Lundell, C. L.** Studies of Mexican and Central American plants—VII. Lloydia **2**: 73–108. *pl. 1–5+f. 1, 2.* Je 1939.

**MacDougal, D. T.** Features of growth-control in trees. Proc. Am. Philos. Soc. **81**: 421–445. *f. 1–5.* 31 Au 1939.

**Martin, R. F.** Reduction of *Juncus utahensis*. Rhodora **41**: 464. S 1939.

**Martin, W. E.** Nitrogen nutrition in relation to yield and quality of grapefruit. Plant Physiol. **14**: 606, 607. Jl 1939.

**McClintock, B.** The behavior in successive nuclear divisions of a chromosome broken at meiosis. Proc. Nat. Acad. Sci. **25**: 405–416. *f. 1, 6.* Au 1939.

**McFadden, E. S.** Early blackhull resists stem rust in Texas. Phytopathology **29**: 644, 645. Jl 1939.

**Mehlich, A.** Growth of *Cunninghamella Blakesleeana* as influenced by forms of nitrogen and phosphorus under varying conditions. Soil Sci. **48**: 121–133. Au 1939.

**Miller, P. R.** Pathogenicity, symptoms, and the causative fungi of three apple rusts compared. Phytopathology **29**: 801–811. *f. 1–3.* S 1939.

**Miller, P. R.** The relation of aeciospore germinability and dissemination to time of infection and control of *Gymnosporangium juniperi-virginianae* on red cedar. Phytopathology **29**: 812–817. *pl. 3+f. 1.* S 1939.

**Minckler, L. S.** Genetics in forestry. Jour. Forestry **37**: 559–564. Jl 1939.

**Moldenke, H. N.** An alphabetic list of common and vernacular names recorded for members of the Verbenaceae and Avicenniaceae. pp. 1–34. *mimeog.* 31 Au 1939.

**Morris, D. L. & Morris, C. T.** Glycogen in sweet corn. Science **90**: 238, 239. 8 S 1939.

**Morton, C. V.** A revision of *Besleria.* Contr. U. S. Nat. Herb. **26**[9]: 395–474. 1939.

**Moxon, A. L., Olson, O. E. & Searight, W. V.** Selenium in rocks, soils, and plants. Agr. Exp. Sta. South Dakota Tech. Bull. 2: 1–92. *f. 1–27.* My 1939.

**Mullison, W. R.** Electrodialysis of pea seeds. Plant Physiol. **14**: 583–587. *f. 1–3.* Jl 1939.

**Murphy, H. C.** Effect of crown and stem rusts on the relative cold resistance of varieties and selections of oats. Phytopathology **29**: 763–782. *f. 1–4.* S 1939.

**Murrill, W. A.** Alachua orchids—Keys to genera and species, description of species, common names, picking orchids. Contr. Herb. Univ. Florida Agr. Exp. Sta., Gainesville, Fla. *Mimeog.* Au 1939.

**Nearing, G. G.** Guide to the lichens of the New York area—Part 3. Torreya **39**: 93–107. *pl. 5, 6.* Jl-Au 1939.

**Newton, M. & Johnson, T.** A mutation for pathogenicity in *Puccinia graminis Tritici.* Canadian Jour. Res. **17**: 297–299. S 1939.

**Nielsen, E. L.** A note concerning the identity of *Amelanchier florida* Lindley and *A. alnifolia* Nuttall. Am. Midl. Nat. **22**: 207, 208. Jl 1939.

**Nielsen, E. L.** A taxonomic study of the genus *Amelanchier* in Minnesota. Am. Midl. Nat. **22**: 160–206. *f. 1–16.* Jl 1939.

**Northen, H. T. & Northen, R. T.** Effects of cations and anions on protoplasmic elasticity. Plant Physiol. **14**: 539–547. Jl 1939.

**Oort, A. J. P.** Inoculation experiments with loose smuts of wheat and barley (*Ustilago tritici* and *U. nuda*). Phytopathology **29**: 717–728. *f. 1–4.* Au 1939.

**Palmer, E. J.** Some woody plants of Rhode Island. Rhodora **41**: 315, 316. Jl 1939.

**Parlin, J. C.** Some Maine lichens, hepatics, and mosses. Bull. Josselyn Bot. Soc. **7**: 30–59. 1939.

**Penfound, W. T. & Hall, T. F.** A phytosociological analysis of a tupelo gum forest near Huntsville, Alabama. Ecology **20**: 358–364. *f. 1–3.* Jl 1939.

**Pennell, F. W.** A new *Veronica* from New Guinea. Notulae Naturae Acad. Nat. Sci. Philadelphia **23**: 1, 2. 4 Au 1939.

**Pennell, F. W.** On the typification of Linnean species as illustrated by *Polygala verticillata.* Rhodora **41**: 378–384. Au 1939.

**Pfeiffer, N. E.** Life of gladiolus pollen prolonged by controlled conditions of storage. Contr. Boyce Thompson Inst. **10**: 429–440. *f. 1, 2.* Jl-S 1939.

**Phelps, O. P.** *Lygodium palmatum* (Bernh.) Sw. in New York. Am. Fern Jour. **29**: 115–118. *illust.* Jl-S 1939.

**Poellnitz, K. von.** Eine neue Sedum-Art aus Süd-Amerika. Repert. Spec. Nov. **46**: 95, 96. 10 Je 1939.

**Pomerleau, R. & Brunel, J.** Inventaire descriptif de la flora mycologique du Québec VII. Nat. Canadien **66**: 195, 196. Je-Jl 1939.

**Porsild, A. E.** Contributions to the flora of Alaska. Rhodora **41**: 262–301. *pl. 554.* Jl 1939.

**Porte, W. S., Doolittle, S. P. & Wellman, F. L.** Hybridization of a mosaic-tolerant, wilt-resistant *Lycopersicon hirsutum* with *Lycopersicon esculentum.* Phytopathology **29**: 757–759. *f. 1.* Au 1939.

**Preece, W. H. A.** The genus *Petrophytum.* New Flora and Silva **11**: 290–295. *f. 97, 98.* Jl 1939.

**Pryor, D. E. & Walker, J. C.** A method for testing the toxicity of volatile compounds. Phytopathology **29**: 641–643. *f. 1.* Jl 1939.

**Record, S. J.** American woods of the family Bombacaceae. Trop. Woods **59**: 1–20. 1 S 1939.

**Record, S. J.** American woods of the family Sapotaceae. Trop. Woods **59**: 21–51. S 1939.

**Reeves, E. L., Yothers, M. A. & Murray, C. W.** Unusual development of apple perennial canker, following application of toxic wound dressings. Phytopathology **29**: 739–743. *f. 1.* Au 1939.

**Reynolds, E. S.** Tree temperatures and thermostasy. Ann. Missouri Bot. Gard. **26**: 165–255. *f. 1, 2. & charts.* S 1939.

**Righter, F. I.** A simple method of making germination tests of pine pollen. Jour. Forestry **37**: 547–576. *f. 1, 2.* Jl 1939.

**Roberts, J. L. & Roberts, E.** Auxin production by soil microorganisms. Soil Sci. **48**: 135–139. Au 1939.

**Robyns, W. & Lamb, S. H.** Preliminary ecological survey of the Island of Hawaii. Bull. Jard. Bot. Bruxelles **15**: 241–293. *f. 10–43.* Jl 1939.

**Rollins, R. C.** The cruciferous genus *Physaria.* Rhodora **41**: 392–415. *pl. 556+f. 1.* S 1939.

**Rollins, R. C.** The cruciferous genus *Stanleya.* Lloydia **2**: 109–127. *f. 1–3.* Je 1939.

**Ross, A. F., Tottingham, W. E. & Nagy, R.** Characteristics of the tyrosinase system in potatoes which blacken after boiling. Plant Physiol. **14**: 549–557. *f. 1–3.* Jl 1939.

**Santesson, C. G.** Einige mexikanische Rauschdrogen. Ark. Bot. **29**[12]: 1–9. *f. 1.* 1939.

**Sax, K. & Enzmann, E. V.** The effect of temperature on x-ray induced chromosome aberrations. Proc. Nat. Acad. Sci. **25**: 397–405. Au 1939.

**Schaffner, J. H. & Hones, C. H.** Additions to the revised catalogue of Ohio vascular plants. Ohio Jour. Sci. **39**: 232–234. Jl 1939.

**Schall, L. A.** Penetration of potato-tuber tissue by *Rhizoctonia solani* in relation to the effectiveness of seed treatment. Phytopathology **29**: 759, 760. *f. 1.* Au 1939.

**Schweinfurth, C.** Nomenclatorial notes. XI. Harvard Univ. Bot. Mus. Leafl. **7**: 186, 187. 6 S 1939.

**Schweinfurth, C.** Notes on a remarkable collection of orchids from Panama. Harvard Univ. Bot. Mus. Leafl. **7**: 149–156. 8 Au. 1939.

**Seckt, H.** Die pflanzengeographischen Verhältnisse der argentinischen Provinz Córdoba. Repert Spec. Nov. Beih. **111**: 32–45. *pl. 1–7.* 30 Je 1939.

**Senior, R. M.** The flora of South Central Idaho. Quart. Bull. Alpine Garden Soc. **7**: 200–205. *illust.* S 1939.

**Senn, H. A.** North American species of *Crotalaria.* Rhodora **41**: 317–367. Au 1939.

**Seward, A.** The western Isles through the mists of ages. Science **90**: 189–200. *map.* 1 S 1939.

**Shields, A. R.** *Trichomanes Petersii.* A. Grey in North Carolina. Am. Fern. Jour. **29**: 113, 114. Jl-S 1939.

**Shirley, H. L. & Meuli, L. J.** Influence of moisture supply on drought resistance of conifers. Jour. Agr. Res. **59**: 1–21. *f. 1–3.* 1 Jl 1939.

**Sideris, C. P., Krauss, B. H. & Young, H. Y.** Distribution of different nitrogen fractions, sugars and other substances in various sections of the pineapple plant grown in soil cultures and receiving either ammonium or nitrate salts. Plant Physiol. **14:** 227–254. *f. 1–11.* Ap 1939.

**Skottsberg, C.** Remarks on the Hawaiian flora. Proc. Linnean Soc. London **151:** 181–186. 5 Jl 1939.

**Smith, C. B. & Cochran, L. C.** Rust on the California native Pruni. Phytopathology **29:** 645, 646, *f. 1.* Jl 1939.

**Smith, D. J. & Smith, C. O.** The use of special media for sporulation of fungi. Phytopathology **29:** 821. S 1939.

**Smith, H. H.** The induction of polyploidy in *Nicotiana* species and species hybrids. Jour. Heredity **30:** 291–306. *f. 1–9. frontisp.* Jl 1939.

**Smith, P. F.** The influence of 3-indole-acetic acid on pollen germination. Science **90:** 163, 164. 18 Au 1939.

**Smith, W. K.** The alleged protective action of alfalfa against the hemorrhagic sweet-clover disease. Jour. Agr. Res. **59:** 211–215. 1 Au 1939.

**Soxman, G. M.** Distribution of *Adiantum tricholepis* in Texas. Am. Fern Jour. **29:** 119–121. Jl-S 1939.

**Soxman, G. M.** *Lygodium japonicum* in Texas. Am. Fern Jour. **29:** 111. Jl-S 1939.

**Sprague, G. F.** Corn hybrids for Missouri. Univ. Missouri Agri. Exp. Sta. Circ. 201: 1–27. *f. 1–23.* Ja 1939.

**Stafford, D.** On the flora of southern Peru. Proc. Linnean Soc. London **151:** 172–181. 5 Jl 1939.

**Stevens, N. E.** Environmental factors and the wasting disease of eelgrass. Rhodora **41:** 260–262. Jl 1939.

**Stevens, O. A.** Wild flowers of North Dakota. Ext. Ser. Fargo, North Dakota Cir. 164: 1–52. *f. 1–38.* My 1938.

**Stockwell, W. P.** Preembryonic selection in the pines. Jour. Forestry **37:** 541–543. *f. 1–4.* Jl 1939.

**Svenson, H. K.** Dates of Boeckeler's Cyperaceae. Rhodora **41:** 313. Jl 1939.

**Taubenhaus, J. J. & Altstatt, G. E.** Some factors contributing to tomato puffing. Plant. Physiol. **14:** 575–581. Jl 1939.

**Taylor, M. S.** A study of *Nardia Lescurii.* Bryologist **42:** 85–106. *illust.* Au. 1939.

**Thirumalachar, M. J.** Rust on *Jasminum grandiflorum.* Phytopathology **29:** 783–792. *f. 1–3.* S 1939.

**Thompson, R. C. & Kosar, W. F.** Stimulation of germination of dormant lettuce seed by sulphur compounds. Plant Physiol. **14:** 567–573. *f. 1.* Jl 1939.

**Thompson, R. H.** A preliminary survey of the fresh-water algae of eastern Kansas. Univ. Kansas Sci. Bull. **25:** 5–83. *pl. 1–12.* 1 Je 1938.

**Thornton, N. C.** Development of dormancy in lily bulbs. Contr. Boyce Thompson Inst. **10:** 381–388. *f. 1.* Jl-S 1939.

**Tompkins, C. M.** Charcoal rot of sugar beet. Hilgardia **12:** 75–81. *f. 1–4.* O 1938.

**Tryon, R. M.** The varieties of *Convolvulus spithamaeus* and of *C. sepium.* Rhodora **41:** 415–423. *pl. 557, 558.* S 1939.

**Vickery, H. B., Pucher, G. W., Wakeman, A. J. & Leavenworth, C. S.** Chemical investigations of the rhubarb plant. Connecticut Agr. Exp. Sta. Bull. 424: 1–157. *f. 1–38.* My 1939.

**Vinson, C. G., McReynolds, D. K. & Gingrich, N. S.** Virus protein of mosaic disease of tobacco. Univ. Missouri Agr. Exp. Sta. Res. Bull. 297: 1–12. *f. 1–3.* F 1939.

**Wadleigh, C. H.** The influence of varying cation proportions upon the growth of young cotton plants. Soil Sci. **48:** 109–120. *f. 1–4.* Au 1939.

**Wallace, J. M.** Recovery from an acquired tolerance of curly top in *Nicotiana tabacum.* Phytopathology **29:** 743–749. *f. 1–4.* Au 1939.

**Ward, F. K.** Plant hunting in the eastern Himalayas. Gard. Chron. **43:** 267, 268. *illust.* S 1939.

**Wareham, R. T. & Whitney, J. B.** The annulus of *Pottiae truncata* (Hedw.) Fürnr. Bryologist **42:** 106–108. *f. 1–3.* Au 1939.

**Watkins, W. E.** The calcium and phosphorus contents of important New Mexico range forages. Agr. Exp. Sta. New Mexico Coll. Agr. Bull. 246: 1–75. *f. 1–7.* Ap 1937.

**Weaver, J. E. & Hansen, W. W.** Increase of *Sporobolus cryptandrus* in pastures of eastern Nebraska. Ecology **20:** 374–381. *f. 1–5.* Jl 1939.

**Weber, G. F.** Web-blight, a disease of beans caused by *Corticium microsclerotia.* Phytopathology **29:** 559–575. *f. 1–7.* Jl 1939.

**Wiant, J. S., Ivanoff, S. S. & Stevenson, J. A.** White rust of spinach. Phytopathology **29:** 616–623. *f. 1, 2.* Jl 1939.

**Wiggins, I. L.** Folklore and fact of medicinal plants in rural Mexico. Jour. N. Y. Bot. Gard. **40:** 176–179. *illust.* Au 1939.

**Willard, D. R. & Smith, J. B.** The calibration of a constant recording illuminometer when the sensitive sampling surface is horizontal. Plant Physiol. **14:** 595–598. *f. 1, 2.* Jl 1939.

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